FINAL REPORT

Grid-Parity Solar Power for Department of Defense Installations

ESTCP Project EW-201134

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List of Acronyms

Acronym	Definition
A	*Amps*
ABC	*Activity Based Costing*
AOI	*Angle of Incidence*
BLCC	*Building Life Cycle Cost*
BoS	*Balance of Systems*
CIGS	*Copper, Indium, Gallium, Selenium*
CO_2	*Carbon Dioxide*
DC	*Direct Current*
DoD	*Department of Defense*
DoE	*Department of Energy*
eGRID	*Emissions & Generation Resource Integrated Database*
E(I)	*Inflation Rate during the Life of the Camp Roberts Demonstration*
EPC	*Engineering, Procurement, and Construction*
ESTCP	*Environmental Security Technology Certification Program*
GHG	*Greenhouse Gasses*
GW	*Gigawatt. A quantity of power equal to 1 x 10^9 watts.*
kW	*Kilowatt, A quantity of power equal to 1 x 10^3 watts.*
kWh	*Kilowatt-hour. A quantity of energy, equivalent to 1 kilowatt of power for 1 hour.*
i	*Nominal Discount Rate during the life of the Demonstration Project.*
LCOE	*Levelized Cost of Energy. Cost of the energy generating system including all the costs over its lifetime.*
MPa	*Megapascals*
MW	*Megawatt. A quantity of power equal to 1 x 10^6 watts.*
MWT	*Metal Wrap Through*
N	*Life of Energy Plant, equal to 25 years for the Camp Roberts Demonstration*
N2O	*Nitrous Oxide*
NH4	*Methane*
NPV	*Net Present Value*
O&M	*Operations and Maintenance*
OMS	*Online Monitoring System*
PTC	*PVUSA Test Condition: used by state of CA to calculate rebates. 1000 W/m^2 solar irradiance, 20°C air temperature, wind speed 1m/s^2 at 10m above ground level.*
PV	*Photovoltaic*
PVSyst	*University of Geneva energy yield simulation software*
PVWatts	*NREL solar energy yield simulation software*
r	*Real Discount Rate during the life of the Demonstration Project.*
ROI	*Return on Investment*
RV	*Residual Value at the end of Life of an Investment*
SAM	*Sandia/NREL Solar Advisor Model energy yield simulation software*
STC	*Standard Test Conditions. 1000 W/m^2 solar irradiance, 25°C air temperature*
TÜV	***Technischer Überwachungs-Verein***, (English: Technical Inspection Association) are German third party organizations that validate the safety of products of all kinds.

Acronym	Definition
UL	*Underwriters Laboratory*
V	*Volts*
W	*Watt*

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Executive Summary

Background and Intent:

According to the U.S. Energy Information Administration's 2011 Annual Energy Outlook, fossil fuels make up over 85% of the US's current fuel use for energy generation. Despite optimistic growth for the use of renewable energy fuels, the EIA still forecasts over 78% fossil fuel use for energy generation by 2035. In testimony before the US Senate on January 27, 2010, Deputy Undersecretary for Defense for Installations and Environment, Dr. Dorothy Robyn, stated that the military's heavy reliance on fossil fuels creates significant risks and costs at a tactical and strategic level.[1]

The intent of this project was to demonstrate a solar power plant that achieves grid-parity solar power without tax credits or rebates on a DoD installation. For purposes of this discussion, grid-parity is defined as the solar power plant installed and operated at a cost at or below the cost of electricity provided by the local utility, including all energy and demand charges.

Based on data from September 2012 thru August 2013 the blended cost of electricity from the local utility provider was $0.111/kwh.

Solar Power Plant Deployed:

In May of 2012, Nanosolar commissioned a 1MW thin-film, ground-mount solar PV power plant at Camp Roberts, California. Cost cutting features in the plant design included: 1) frameless solar panels manufactured with a unique, low-cost, printed CIGS technology; 2) larger 1,937mm x 1,034mm panels than current, typical panels resulting in a lower Balance of Systems (BoS) racking, cabling, and home run cost; and 3) under-grounded cable plant design. Capital and operating costs for the project are summarized below.

TABLE 1: SUMMARY OF CAPITAL AND MAINTENANCE COSTS[2]

Item Description	Cost
Design and Permitting	Included
Solar Panels	Included
Inverters	Included
Racking	Included
BoS	Included
Total Capital Cost (Includes additional $168K for Davis/Bacon labor rates & archeological oversight fees)	$3,430,000
Annual Operations and Maintenance (year 1)	$28,000

[1] Statement of Deputy Under Secretary of Defense for Installations and Environment Dr. Dorothy Robyn Before the Senate Homeland Security and Governmental Affairs Committee Subcommittee on Federal Financial Management, Government Information, Federal Services and International Security January 27, 2010.

[2] A complete breakdown of Total Capital Cost including design and permitting, inverters, racking, and other BoS components was not made available by Belectric. Total capital and maintenance cost is based on contract pricing, and this contract pricing is used for all calculations where cost is a required input.

This project demonstrated that several key objectives could be met with respect to distributed generation, including achieving a LCOE of $0.115/kWh at an installed cost of $3.44/W.[3] This project thereby demonstrated a means for the DoD to stabilize increasing utility costs at installations nationwide with solar electricity.

Due to adverse market conditions, Nanosolar ceased their manufacturing operations in October 2013. Unfortunately, similar to other American solar panel manufacturers, Nanosolar was unable to avoid effects from the rapid and persistent decline in solar prices caused by certain countries flooding the American market with large quantities of low cost solar panels. However, the price decline of solar components used in the design and construction of solar plants means solar energy production can achieve grid-parity in many markets. This is particularly true in markets with high solar irradiance and daytime peak-time rate structures.

The DoE, DoD, and other stakeholders should consider the strategic national and economic security implications of the loss of American-based solar renewable energy technology leadership and the loss of American solar manufacturing capability.

Performance Results:

The goal of this project was to demonstrate the economic viability of distributed solar generation for the US Military. Table 3 (page 16) summarizes the performance of the project versus the defined success criteria and as detailed in the table, most of the objectives were met in the demonstration.

NOTABLE QUOTES

"Nanosolar's 1MW system at Camp Roberts, CA is a great example of how the Department of Defense is using its military installations as Test Beds for new energy and energy efficiency technologies. The excellent performance during the first several months of electricity generation from Nanosolar's PV panels provides very promising initial results that the DoD Test Bed Program will continue to monitor and evaluate. Nanosolar's demonstration of its product at Camp Roberts is enabling DoD to gain valuable insights on the challenges and opportunities of hosting distributed generation on its facilities."

Program Manager, Energy & Water – ESTCP
Dr. James Galvin

"When the troop load is down, the meter will spin backwards. You can literally see the electricity go back into [Pacific Gas & Electric's] grid to be used by somebody else."

Project Manager
Col. Walter Goodwater (retired)

"We think it has real promise for grid parity prices, and we are testing that at Camp Roberts in California."

DOD Deputy Under Secretary of Defense for Installations and Environment
Dr. Dorothy Robyn

1.0 INTRODUCTION

This final report is part of the Energy Security Technology Certification Program (ESTCP) by the Department of Defense (DoD). As part of ESTCP, Nanosolar implemented its commercially-available thin film solar technology to construct a 1MW DC free field, ground-mounted solar demonstration project sited at Camp Roberts of the California National Guard.

The Nanosolar demonstration solar power plant illustrated that DoD military installations throughout the U.S. can benefit from competitive electricity costs through on-site, distributed solar generation. This demonstration showcased that U.S.-developed and manufactured solar technology and products—and U.S.-generated solar power—can provide energy security and independence to the U.S. military. Similar projects ranging from 1 to 20MW could enable distributed power to be produced within existing distribution lines, which avoids expensive transmission step-ups and tie-ins. This range of power plant outputs could be readily constructed at DoD installations nationwide.

The construction phase of this project was completed in May of 2012, with the connection of the solar power plant to the PG&E grid. Testing and monitoring of the system per project goals is complete, and these activities ran for 12 months duration after plant connection to the grid and a short conditioning period during which the solar panels ramp to full energy generation capacity.

1.1 BACKGROUND

According to the U.S. Energy Information Administration's 2011 Annual Energy Outlook, fossil fuels make up over 85% of the US's current fuel use for energy generation. Despite optimistic growth for the use of renewable energy fuels, the EIA still forecasts over 78% fossil fuel use for energy generation by 2035.

Of the estimated 250 GW of additional energy capacity that DOE, EIA forecasts to come online between 2008 and 2035,the EIA attributes 46% to natural gas plants and 12% to new coal plants. Only 37% of forecast energy production is attributed to newly built renewable energy plants. Dorothy Robyn, the Deputy Undersecretary of Defense for Installations and Environment, recently testified to the US Senate that the military's heavy reliance on fossil fuels creates significant risks and costs at a tactical and strategic level.[4]

The DoD's use of renewable solar energy to-date has been tied to Enhanced Use Lease Agreements and Federal and State solar incentives, in the form of tax credits and artificially high prices for the renewable energy credits generated. These incentives mask the reality that the approximately ten solar PV projects implemented to-date nationwide on DoD installations are not cost effective without incentive support, having cost over $6/watt fully-installed on a national average, or over $0.300/kWh at a levelized cost of energy (LCOE).[5]

As part of ESTCP, Nanosolar built a 1MW free field, ground-mounted solar demonstration project for Camp Roberts, California, where solar irradiance is above-average as compared to many other U.S. geographies.

[4] See Note 1.
[5] Science Daily and Think Progress.

1.2 OBJECTIVE OF THE DEMONSTRATION

The mission of the ESTCP demonstration is to:

- Demonstrate that solar power can cost-effectively provide the energy security, reliability and independence required for U.S. military installations while concurrently meeting our Federal renewable energy goals of 25% renewable by 2025 (EPAct and Executive Order 13423).
- Demonstrate that Nanosolar, a San Jose, CA based manufacturer of solar cells and panels, could build such a solar power plant with low-cost solar cells manufactured in the U.S.
- Design and build a Nanosolar power plant for $3.20/watt DC fully-installed, or less than 11 cents/kWh (LCOE), thereby demonstrating a means for the DoD to stabilize increasing utility costs at installations nationwide with solar electricity.
- Create a set of standard solar power plant designs to enable the DoD to install solar power at installations nationwide at or near grid parity as measured by LCOE electricity costs.

1.3 REGULATORY DRIVERS

The U.S. DoD spends over $4 billion annually on electricity use, and when combined with over $12 billion of Operational Energy costs, the DoD accounts for over 75% of the Federal Government's total energy usage. The DoD's January 29, 2010 announcement that it will reduce greenhouse gas emissions from non-combat activities 34% by 2020 recognizes that the DoD can have a leading impact on reducing our country's carbon emissions: http://www.defense.gov/releases/release.aspx?releaseid=13276

Two drivers for this announcement were the DOD's Strategic Sustainability Performance Plan and Executive Order 13514. The Strategic Sustainability Performance Plan states that the DoD will promote sustainability and reduce their reliance on fossil fuels. Executive Order 13514 states that the military and government will lead by example in reducing their greenhouse gas emissions. Executive Order 13514 adds to Executive Order 13423, which states that the military is to contribute to achieving the federal renewable energy goals of 25% renewable.

2.0 TECHNOLOGY DESCRIPTION

Conventional solar cell manufacturing processes often utilize very expensive vacuum deposition and sputtering equipment in clean room environments, thus driving up costs for traditional panels. However, Nanosolar utilizes highly innovative nanotechnology to enable high-volume production of low-cost solar panels. Nanosolar "prints" a layer comprised of a nanoscaled structured suspension of copper, indium, gallium and selenium onto aluminum metal foil with a slot-die coater. The printed material is dried in an oven before subsequent processing.

After properly dried, the printed rolls are then transformed into an opto-electronically mature crystalline semiconductor through several roll-to-roll rapid thermal processes. Individual solar cells are then spliced, measured, interconnected and assembled into solar modules. The production process is highly automated in a non-clean room production setting using relatively standard equipment and processes with few modifications, which substantially lowers the cost of manufacturing panels.

2.1 TECHNOLOGY OVERVIEW[6]

Streamlined Solar Cell Architecture

Nanosolar's proprietary cell innovations have focused on developing and demonstrating improved processing for solar photovoltaic technology, in particular through the use of scalable process technology with higher intrinsic deposition throughput, yield, and uniformity. More specifically, Nanosolar developed its cost-efficient panel technology based on design, development and use of five bodies of technological innovation:

(1) A highly conductive, low-cost aluminum foil as the substrate and bottom electrode of the cell;

(2) CIGS "ink" with loaded-in stoichiometric ratio and a high-yield high-throughput printing process to form an electronic grade CIGS semiconductor;

(3) A novel Metal-Wrap-Through (MWT) back-contact design based on high throughput foil lamination;

(4) A thin/printed transparent top electrode; and

(5) Redesign and development of materials deposition processes that work with and leverage the superior steady-state uniformity and other characteristics inherent in roll-to-roll processing.

These five bodies of innovation address each component of a solar cell's cost and capital efficiency, delivering the definitive improvement necessary to obtain an ultra-low-cost product. Innovation (1) delivers low materials cost, a low-cost substrate, and a low-cost bottom electrode (which otherwise would have to be created through an expensive thin film). Innovations (2) and (5) deliver a low-cost absorber/semiconductor with high material utilization and capital efficiency. Innovations (3) and (4) enables a low-cost top electrode and simple, fast, robust cell interconnects. The combination of a highly conductive substrate (aluminum) with Nanosolar's MWT cell architecture resulted in cells capable of generating and carrying currents of 6-25 Amps, or 300-1,000% more than is cost efficient with other state-of-the-art thin-film solar cells today. Panels

[6] As a result of Nanosolar's decision to cease operations by October, 2013, the IP associated with this and all Nanosolar technology is currently available for bid. Contact AERIS Capital, http://www.aeris-capital.com, for more information.

built with such high-current cells result in significantly lower balance-of-system costs when deploying large-scale systems.

In late 2012 and 2013, Nanosolar further reduced the cost of its product primarily by reducing the cost of Innovation (3). This cost reduction was not included in the demonstration project and so does not factor into System Economics (LCOE) calculations.

Design of the Nanosolar Utility Panel

Designed to reduce total-system cost, the Nanosolar Utility Panel is electrically and mechanically optimized for utility-scale solar power systems. The Nanosolar Utility Panel is specifically designed and developed for utility-scale systems where the size of deployment ranges from 1-50MW in size. The scale of these types of deployments both afford and require a level of industrial streamlining and optimization that is different from smaller-scale systems.

Electrically, the product is the industry's highest-current thin-film panel by as much as a factor of six (at over 6A). It is also the industry's first photovoltaic panel certified by TÜV for a system voltage of 1,500V, or 50% higher than the previously highest certified 1,000V. Combined, this enables longer panel arrays, resulting in a host of cost savings during installation. In addition, the panel is the industry's first solar panel with an edge connector, the Nanosolar Edge Connector, simplifying cabling, minimizing resistive losses, and enabling higher system voltage in solar power plants.

Mechanically, the dual-tempered glass-on-glass package used for the panel is distinctly stronger than conventional thin-film-on-glass panels, delivering almost twice the mounting span and correspondingly lowers mounting materials requirements, while not adding additional weight. Additionally, this package design has the advantage of not requiring metal framing components which add complexity and cost as compared to glass.

Mechanically Strong Package for Wide-Span Mounting

Whereas traditional thin-film-on-glass panel manufacturers deposit the solar-cell stack of thin films directly onto a glass pane enclosure to prevent moisture ingress Nanosolar uses a sorted cell assembly coupled with dual tempered glass pane enclosures. Nanosolar produces individual foil cells, sorts them into electrically matched circuits, and assembles that circuit into a panel.

The Nanosolar Utility Panel uses tempered glass on both front and back of its glass/glass package. The use of two tempered glass panes is not possible for producers of thin-film-on-glass panels because the high-temperature cell production process will de-temper the glass substrate.

The use of dually tempered glass panes, with Nanosolar's foil cells in between, creates a package of superior mechanical strength. Tempered glass has strength of 120MPa, or three times stronger than regular glass. The resulting system benefit is that it enables wide-span mounting. Wide-span mounting reduces the cost of mounting steel and associated materials substantially. By utilizing sorted-cell assembly, Nanosolar gains a panel assembly yield advantage and flexibility in terms of panel size, form factor, and package style.

High-Current, High-System-Voltage Design for Utility-Scale Panel Arrays

Series-interconnected Nanosolar cells have the unique capability to generate and carry much higher currents without any significant resistive losses. High current cells are desirable for utility-scale system implementations because they simplify DC cabling and save balance-of-system cost. They allow larger numbers of panels to be interconnected in series without the expense of additional cabling home runs to the inverter. If the panel's current is low (as is the case with many thin-film-on-glass products), then for the same amount of installed power, the system voltage is reached more quickly through a relatively small number of interconnected panels, and a higher effort in cable splicing or home runs is required.

The electrical characteristics of a panel combine with its mechanical length to determine the panel array length or the maximum length of a row of panels in a large-scale system possible without running additional cables back to the inverter. The panel array length is calculated by dividing the panels' system voltage by its open-circuit voltage (at low temperature) and then multiplying by the panel length in mounting orientation.

The Nanosolar Utility Panel supports a panel array length of 64m, which is more than five times longer than leading thin-film panels presently installed in large-scale fields. The difference is large in utility scale systems where distances are great; large amounts of expensive DC cabling can be required, and longer panel array length reduces cabling requirements by as much as 73%.

Nanosolar Edge Connector for Fast, Minimal-Resistive-Loss Interconnection

Nanosolar has developed a new form of cabling connection for the Nanosolar Utility Panel. A component separately tested and certified by TÜV according to applicable connector standards for power connections, the Nanosolar Edge Connector, is designed to reduce cabling labor, save material cost, and minimize resistive losses for the kinds of installations used in utility-scale system deployments.

2.2 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

Advantages

Nanosolar's innovative printing technology allows for cheaper production of PV panels and lower BoS cost. Nanosolar panels also have shorter construction and installation times than other thin film companies, particularly on sites where power-assist equipment can be utilized. This is because Nanosolar manufactures larger panels that require fewer mounting fixtures than their competitors.

Limitations

The primary risk for this demonstration project was the potential for a significant environmental impact. Clearing of land is necessary to install these power facilities. The clearing of trees in the area, while necessary for proper installation and operation, can have adverse effects on the surrounding flora and fauna. As installed, this was not an impact for the project.

Another risk for this demonstration project was the potential for a significant increase in the commodity price of raw materials, which could have impacted Nanosolar's ability to deliver the

proposed solar power plant at the target cost. As installed, this was not an impact for the project because Nanosolar's Supply Chain organization had necessary capability to control costs during the project.

In addition, the Nanosolar Utility Panel has a limited field operating record, limiting Nanosolar's ability to precisely forecast the plant's projected performance over its 25-year lifetime. Nanosolar mitigates this risk by conducting extensive, on-going reliability and outdoor testing well beyond IEC compliance limits**.**

3.0 PERFORMANCE OBJECTIVES

This project was designed to provide a solution for the Department of Defense's renewable energy needs. The objective was to demonstrate that solar power can cost-effectively provide energy security, reliability, and independence required for U.S. military installations while concurrently meeting Federal renewable energy goals of 25% renewable by 2025. Nanosolar designed and built a power plant for $3.44/watt DC fully-installed, and $0.115/kWh[7] (LCOE in real dollar amount), thereby demonstrating a means for the DoD to stabilize increasing utility costs at installations nationwide with solar electricity.

$0.11/kWh was chosen as the LCOE Performance Objective Metric since, at the time of the demonstration, Camp Roberts was covered by the E20P/NEMEXPM rate schedule which includes the following energy charges resulting in an current average cost of electricity of approximately $0.11/kWh. Table 3 provides a breakdown of energy rates by time of day and season.

Table 2: Electricity Rates for Camp Roberts

	Total Electric Rates ($ per kWh)
Peak Summer	$0.13186
Part-Peak Summer	$0.09357
Off-Peak Summer	$0.07117
Part-Peak Winter	$0.08924
Off-Peak Winter	$0.07465

[7] See Note 4.

3.1 PERFORMANCE OBJECTIVES

TABLE 3: SUMMARY OF PERFORMANCE RESULTS

Performance Objective	Metric	Data Requirements	Success Criteria	Results
Quantitative Performance Objectives				
System Economics (LCOE).	$0.110/kWh real dollar LCOE. $3.20/W solar power plant cost.	Energy generated & performance degradation. Cost of solar plant design, construction and installation.	Energy produced is equal to or greater than simulated results. Cost of project at or under budget.	$0.115/kWh real dollar LCOE.[8] $3.44/W solar power plant cost.[9]
Greenhouse Gas Emissions Reduction.	309kg CO2/kWh savings (base-load output).[10]	Energy produced by solar panels. CO2 emissions of alternative electricity generation methods.	Calculated savings is equal to or greater than expected results.	Calculated amount of CO2 saved is 783,420kg.[11]
Reliability.	99.0% uptime.	The amount of time the system is operating per design.	Uptime equals estimates.	Uptime 98.4% per data from Meteocontrol.
Photovoltaic Peak Capacity (Installed).	MW DC.	Installed capacity of panels.	Capacity of 1 MW DC.	Capacity = 998.4 kWp DC.
Photovoltaic Peak Capacity (Power Delivered).	PVSyst estimate, 1,638 MWh AC (Weather Adjusted).	Power delivered to Camp Roberts over the entire year.	Matches estimates with less than or equal to 3% degradation of power peak delivered.	Actual = 1650 MWh AC.
Renewable Energy Produced.	PVSyst estimate, 1,638 MWh AC (Weather	Energy produced over an entire year.	Matches or exceeds estimates from	Actual = 1650 MWh AC.

[8] See Appendix I for LCOE Calculation details. See Note 3 for additional details.
[9] See Note 3.

[10] Savings via avoidance of the use of energy generated by California utilities, the majority of which is natural gas. Nanosolar panel lifecycle emissions are approximately 14g CO2/kWh.
[11] See Note 7.

Performance Objective	Metric	Data Requirements	Success Criteria	Results
	Adjusted).		PVSyst.	
Site Maintenance.	Months, number of panels replaced.	Cleaning and maintenance schedule.	Site maintained to specifications provided.	Complete. Replaced 9 panels due to infant mortality.
Installed Cost.	$/W DC.	Dollar costs, photovoltaic capacity.	Less than $3.20/W DC.	$3.44/W DC.[12]
Qualitative Performance Objectives				
User Satisfaction.	Degree of Satisfaction.	Stakeholder Interviews & survey.	Good results reported from demonstration project.	High degree of satisfaction reported from stakeholder interviews.

3.2 PERFORMANCE OBJECTIVES DESCRIPTIONS

System Economics

The main goal of this project was to achieve a real Levelized Cost of Energy (LCOE) that is at or below grid parity as measured by the average utility pricing paid by the Camp hosting the project site. LCOE is an economic assessment of the true cost of solar electricity calculated by dividing a solar plant's total costs over its lifetime by the kWh generated over its lifetime. Costs include the initial cost of components (solar panels, mounting, cabling, inverters, and other Balance of Systems (BoS) equipment), installation, operations and maintenance costs, and any cost of capital.

Green House Gas Emissions

In addition to substantial cost savings--over 43% versus past solar PV projects implemented to date nationwide on DoD installations[13]--Nanosolar technology helps the DoD meet its commitment to reduce carbon emissions. A complete lifecycle analysis[14] shows Nanosolar panels generate 14 grams of CO_2 per kWh of solar electricity generated. This compares to 13 grams for renewable wind power, 39 grams for conventional crystalline silicon solar technology, 55 grams for nuclear power, 400 grams for a combined-cycle natural gas plant and 1000 grams for coal-fired electricity. Nanosolar's lifecycle analysis includes:

- Extraction and processing of raw materials
- Production into solar cells and panels
- Assembly and installation into solar power plants

[12] See Note 2.
[13] 43% computed using $3.44 calculated per watt cost vs. assumed $6/W for past DoD projects.
[14] Reference: CCLA Columbia University.

- Operations and maintenance over 25 years
- End-of-life solar plant recycling

California uses about 265,000 GWh of electricity per year andconsumption is growing at a rate of 2% annually. In the last decade, between 29% and 42% of California's in-state generation used natural gas. Another 10% to 20% was provided by hydroelectric power that is subject to significant annual variations. If we avoid consuming electricity from California's utility, then we can expect to save about 309 g/kWh specifically in California where a majority of the power generated is from natural gas plants[15].

For the Camp Roberts demonstration project, it is important to differentiate base-load vs. non-base-load emissions. PV power plants typically produce maximum output when user demands are highest (afternoons). This corresponds to the times when utilities must generate additional power, which is often done with natural gas peaker plants. Consequently, emissions saved calculated using non-base-load emissions factors are most relevant to the project.

Reliability

The reliability of the system is defined as the amount of time the system performs as designed. This includes uptime of all components of the plant including the solar panels, inverters, and all BoS Components.

Photovoltaic Peak Capacity (Installed)

The nameplate capacity of the Camp Roberts demonstration plant is 998.4 kWp DC comprised of 4,992 panels at 200 Watts each.

Photovoltaic Annual Output (Power Delivered)

The power delivered to Camp Roberts should match or exceed results simulated using the University of Geneva energy simulation software, PVSyst. PVSyst calculations state that 1638 MWh should be produced and delivered in one year. The simulation includes calculation factors to account for panel soiling, AC and DC wiring losses, sun irradiance variation, plant uptime, and other influences on energy output.

Renewable Energy Produced

The energy produced indicated the amount of annual energy, in MWh, that the system provided to Camp Roberts during the 12 month operational testing phase. Data was collected from the online performance monitoring equipment and compared to the computer model produced by PVSyst. The PVSyst estimates, which use average weather conditions for calculations, show that the system should produce 1638 MWh/year.

Site Maintenance

The site was maintained so that the power delivered to camp Roberts was not obstructed from soiling losses beyond what is accounted for in estimates. The PVSyst estimates 2% soiling losses in the system.

Site maintenance included the following:

[15] Reference: eGRID.

- A schedule for cleaning the panels, which would include washing once a year
- Maintaining the grass so that no shading of the panels occurs, including mowing three to four times a year, as well as performing weeding and applying herbicide
- Inspecting components of the system and proactively trouble shooting & fixing in advance other issues that may affect performance

Installed Cost

Installed costs for this demonstration plant are estimated to be at $3.20/W DC, or a total of $3.2 million for the entire system.

User Satisfaction

Customer satisfaction assessment is an important component of any technology demonstration project. For the Camp Roberts project, stakeholder interviews and an Excel-based survey will be completed after 1 year of project operation. Stakeholders will include, but are not limited to, Camp Roberts' staff, maintenance contractors, construction crew, and security personnel. Since the project was implemented, the actual number of interviews sent out was five (5) due to changes in personnel.

For the Excel–based survey, 26 questions have been designed so that customer satisfaction with each phase of the project can be assessed. Phases to be assessed include:

- Design and Development Phase
- Project Construction Phase
- Operations and Maintenance Phase
- Other (This portion of the customer satisfaction survey is intended to capture comments, suggestions, or improvements regarding what should be done for future projects that do not fall easily under the previous categories)

Additionally, stakeholders will be asked to provide their evaluation of overall system performance.

To ensure customer satisfaction input is unbiased, respondents to the Excel – based survey are asked to evaluate a series of statements using the following criteria:

- Highly Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Highly Agree
- Not Applicable or No Opinion

Comments are requested of all respondents, and are particularly useful in areas where the demonstration project did not meet expectations.

4.0 FACILITY/SITE DESCRIPTION

Camp Roberts is run by the California National Guard and is located directly off of Highway 101 in Monterey and San Luis Obispo Counties. Camp Roberts address is as follows:

Hwy 101, Bldg 108
Camp Roberts, CA. 93451-5000

4.1 FACILITY/SITE LOCATION AND OPERATIONS

Camp Roberts hosts training for both the National Guard and Army Reserve. The Deployment Site does not interfere with Camp Roberts' training facilities, as the site is outside of the main base to the east of Highway 101. As a result, personnel working on the project will not need military clearance to reach the site.

The Deployment Site at Camp Roberts, CA, has fourteen flat and minimally-shadowed acres available in an area that has already incurred substantial environmental change over the past 70 years. Minimal additional environmental impact was generated based on the final site design, and this carried through to construction, commissioning, and maintenance during the first year of plant operations. Five acres were required for the 1MW plant. Transmission lines run through the site facilitatinginterconnection.

Figure 1: Satellite vicinity map of project area

4.2 FACILITY/SITE CONDITIONS

Several site regulations and permits were needed while project personnel were on the demonstration site. They were as follows:

Section 106 Compliance

In accordance with Section 106 of the National Historic Preservation Act (NHPA), the management of cultural resources for the Nanosolar project at Camp Roberts involved:

- Identifying the Area of Potential Effect (APE);
- Reviewing existing information on historic properties within the APE;
- Obtaining information from consulting parties and other individuals and organizations likely to have knowledge of, or concerns with, historic properties (i.e. local indigenous peoples, local historical societies, etc.);
- Identifying historic properties through research survey, informant interviews, and monitoring;
- Resolving adverse effects through data recovery.

The site was surveyed and no historical properties were identified. However, an archeological site is in the immediate vicinity, and this required that all military and construction personnel on the project received a cultural resource brief prior to the beginning of construction. An archeologist was also present for all ground disturbing activities.

Unexploded Ordnances

Since Camp Roberts is a military training ground, all personnel working in the construction area received a briefing from Camp Robert's staff regarding unexploded ordnance protocol. Unexploded ordnance is explosives (bombs, bullets, shells, grenades, land mines, naval mines, etc.) that did not explode when they were employed and still pose a risk of detonation. Risk of finding unexploded ordnance in the area was extremely low, as the demonstration site was never a training ground or in the immediate vicinity of one. All aspects of the project, including construction were completed on site without issue regarding unexploded ordnances.

PG&E Interconnect

Three permits and documentation were submitted to PG&E regarding interconnection to the solar farm. They are as follows:

1. PG&E Form 79-974 "Generating Facility Interconnection Application"

2. PG&E Form 79-978 "Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities"

3. PG&E Form 79-998 "Expanded Net Energy Metering (NEM) Supplemental Application"

5.0 TEST DESIGN

The demonstration utilized a standard, cost efficient, fixed tilt, and free field mounting design implemented by Nanosolar and Belectric, one of Nanosolar's EPC partners. The design consists of an aluminum and glulam beam installed on a free field to mount the 10% efficient Nanosolar Utility Panels. Also included is an industry-leading central inverter with 96%+ efficiency.

The wood member is pressure treated and has a bitumen paper covering for weather protection. Initially the wood beam was used to accommodate terrain irregularities as well as provide flexibility during construction. Additionally, it has the benefit of enabling the plant owner to modify panel tilt in a straight-forward fashion if site conditions or other factors require this. Lastly, the wood members are cheaper than steel beam while offering the same duty (life) cycle.

All system components are UL certified for installation and operation in the U.S. All mechanical and electrical components have a 25-year life, except for the electrical inverter, which will need to be replaced after 12 years. System components are chosen due to their cost efficiency and high performance.

A web-based performance monitoring system, with appropriate security, was included in order to measure and analyze system performance at 15-minute increments, as well as to help calculate the LCOE. Additionally, this system enables stakeholders to view system performance conveniently.

5.1 CONCEPTUAL TEST DESIGN

The test monitoring system uses an online monitoring system to record ambient temperature and wind speed, as well as irradiance, voltage, and current output from the solar panels. The size of the panel array, tilt, and orientation of the panels remained constant for the duration of the testing period. Testing also verified whether the panels remained within the warrantee specifications.

Panel performance did not show degradation beyond what is stated in the design during the full year of operation. Data collected was normalized to Standard Test Conditions (STC) to compare the data and perform cost and performance analysis on the system.

There are three main phases involved in the testing stage of Nanosolar's system:

1) Preconditioning of Panels: During the first month of field operation Nanosolar panels typically do not perform as well as specified in warrantee or design. They must be preconditioned by the sun before full operation can begin.
2) Monitoring: This is where the online monitoring system will take data using a wide array of sensors, such as pyrometers to measure irradiance and thermocouples for ambient temperatures. All data is sent to our database for storage.
3) Analysis of Data: Once monitoring was complete the data was normalized and analyzed for cost and performance.

5.2 BASELINE CHARACTERIZATION

The baseline characterization for the test is based on industry standard, which is the STC Watt peak sold. The Watt peak sold is based on the Name Plate Rating (STC Rating) of the panels shipped to the Camp Roberts.

5.3 DESIGN AND LAYOUT OF SYSTEM COMPONENTS

The following figures are pictures of the overall system installed at Camp Roberts:

Figure 2: Site prior to installation

Figure 3: Final Power Plant as Installed

Figure 4: Grid connect ceremony at Camp Roberts: May 2012

5.4 OPERATIONAL TESTING

Operational Testing of Cost and Performance

Activity-Based Costing to Assess Labor Cost Drivers during System Deployment:

An activity-based costing analysis was planned to monitor the estimated installation costs associated with labor during the installation of the test deployment. As a result of Nanosolar's decision to cease operations by October, 2013, this analysis was not completed.

Levelized Cost of Energy:

The metric most commonly used to compare energy projects is levelized cost-of-energy (LCOE). LCOE is the average price of electricity throughout the life of a power plant. LCOE takes into account every cost incurred with an energy-generating system over its lifetime including:

- Initial investment
- On-going operation and management
- Cost of fuel
- Cost of capital

To calculate LCOE, a power project's expected lifetime cost structure is discounted using a standard discount rate to yield the Present Value (PV). Lifetime cost structure is the project cost plus on-going operational and maintenance costs over the life of the power plant, minus any residual value at the end of the project. Project cost is tracked during the construction phase of the project, while the operational costs are monitored for one year and extrapolated to yield the 25 year O&M costs.

Next, the electricity output over the plant's lifetime is computed, using the first-year actual energy produced, and extrapolating it to yield the 25 year energy produced. The extrapolation uses a degradation factor to ensure accuracy, as solar panels produce slightly less energy each year they are in the field. For the Camp Roberts demonstration project using Nanosolar technology, the degradation factor is 0.8% per year.

Finally, the Present Value of the annualized costs is divided by the project's energy output to obtain the LCOE. LCOE can be a constant, or nominal, dollar value which excludes inflation, or a current, or real, dollar value which includes inflation.

Formulaically, LCOE can be shown as:

$$Cost\ Structure = Project\ Cost + Operations - Residual\ = Project\ Cost + \sum_{n=1}^{N} \frac{AO}{(1+DR)^n} - \frac{RV}{(1+DR)^n}$$

and

$$Electricity\ ouput\ = Original\ derated\ electricity * annual\ degradation = \sum_{n=1}^{N} \frac{Initial\ KWh\ X\ (1 - System\ Degradation\ rate)^n}{(1+DR)^n}$$

where:

- AO = Annual Operation and Maintenance
- RV = Residual Value
- N = Plant Life
- DR = Discount Rate (Nominal or Real)

The Fisher equation in economics estimates the relationship between nominal and real interest rates under inflation, and the following formula applies:

$$Real\ Discount\ Rate\ = r\ = \frac{1\ +\ i}{1\ +\ E(I)} - 1$$

where:

- i = Nominal Discount Rate
- E(I) = Inflation

Nanosolar also calculates the cost of the entire system with respect to $/watt, or the total installation expenses over the peak power rating of the system, in this case 1MW. This calculation is often used to estimate the value of the investment in the system at the time of purchase. The target for this project is to install the 1 MW system for $3.20/watt or less for a total cost of approximately $3,200,000.

DOE calculations generally make use of real LCOE calculations as opposed to nominal LCOE. This proposal is focused on the measurement of real LCOE. Nanosolar's target real LCOE for this project is less than or equal to $0.11/kWh, which is the pricing threshold equivalent to grid-parity pricing as measured against the average utility rate expenses at Camp Roberts.

Modeling and Simulation

Solar Advisor Model:

The Solar Advisor Model (SAM) (https://www.nrel.gov/analysis/sam) combines a detailed performance model with several types of financing for most solar technologies. In 2004, the National Renewable Energy Laboratory (NREL), in conjunction with Sandia National Laboratory and in partnership with the U.S. Department of Energy (DOE) Solar Energy Technologies Program (SETP), developed SAM. The model is updated on a periodic basis. SAM incorporates the best available models to provide optimal analysis of overall economics, including the levelized cost of energy, stemming from the impact of changes to the physical PV plant.

PVSyst Model:

PVSyst is the PV production simulation tool of choice for the major solar financing entities as it takes into account not only the environmental data of a given site but also accounts for system losses due to design, O&M choices, technology-specific losses and system degradation. The Solar Advisor Model (SAM) typically gives higher production estimates than PVSyst. PVSyst appears to yield the most conservative results of any modeling software.

Nanosolar primarily used the PVSyst model for the Camp Roberts demonstration because it provided more accurate results for modeling performance of Nanosolar's panels due to its complete set of module parameters. SAM does not contain accurate parameters for this demonstration project.

Model Inputs for Solar Plant Performance Monitoring: Supervisory Control and Data Acquisition:

A key input into PVSyst's LCOE calculation is the power output of the test deployment. To measure the power output of the test deployment, the solar plant implemented a supervisory control and data acquisition (SCADA) system that allowed Nanosolar and Belectric to monitor and access real life performance data. Instant weather and insolation information was gathered along with the photovoltaic source circuit characteristics to ensure optimal performance as well as understand the behavior of Nanosolar's technology in real life conditions. The DC circuit combiner units has both voltage and amperage sensors to reach the desirable granularity needed for Nanosolar's study.

Timeline

After grid connect and conditioning, Operational Testing took place over a 12 month period, from Aug 2012 to Jul 2013.

Technology and Transfer

As a result of Nanosolar's decision to cease operations by October 2013, the only design standard published was the "As-Built" documentation for the 1MW system dated October 19, 2012. The 3MW and 5MW reference design plans were not completed.

5.5 SAMPLING PROTOCOL

For performance monitoring, data samples were taken every 15 minutes with a five minute delay in data for the duration of the 12 month period. The data was collected by the online monitoring system (OMS) with limited interaction from any technicians. Meteocontrol was the program of choice for the OMS. Meteocontrol is ideal because it can be located outside the Camp Roberts firewall system and not to interfere with base operations.

As for security of the OMS system, both the weblog and portal were password protected for remote and local access. The Web'Logs are hard coded to transmit data only to Meteocontrol's server IP's and email. SMS alert messages were sent only to designated recipients. Those designations can only be enabled by users with password access to the weblog. The monitoring devices along with a Satcon inverter, recloser, revenue grade meter, and weather sensors were exclusively hardwired into the designated monitoring ports of the Web'Log.

5.6 SAMPLING RESULTS

Equipment calibration and data quality were addressed as issues presented themselves and were not a material factor during the demonstration project because the project experienced minimal detrimental issues.

An example of the online monitoring output is included below for reference. Typically, power output charts are very smooth, and as a consequence, not interesting for discussion purposes. Unlike nearly every day during the 12 month demonstration, data output on 15-August, 2012, indicated a potential issueAs shown in Figure 5.

Figure 5: kWh Output of Camp Roberts for 15 Aug 12

In figure 5, indicated power fluctuated from 0W to well over 1,100W during a 12 hour period. Since this is extremely unlikely, this data triggered analysis by maintenance personnel and the anomaly was addressed quickly. Nanosolar was pleased with the quality of data and performance of the OMS during the demonstration timeframe.

6.0 PERFORMANCE ASSESSMENT

Performance Objectives Analysis Overview

System Economics: Verifying an LCOE of 11 cents/kWh or less:

LCOE Assumptions and Data for Calculations:

For the Camp Roberts demonstration project, real-dollar LCOE is the PV Plant System Economics metric, as described in b), below. However, LCOE computed inclusive of tax credits and/or without inflation factors is informative. Consequently, four different LCOE values are calculated:

a) $/W assuming no tax credits and nominal interest rate
b) $/W assuming no tax credits and real interest rate
c) $/W assuming a 30% tax credit and nominal interest rate
d) $/W assuming a 30% tax credits and real interest rate

LCOE calculated using d), above, is relevant to actual Camp Roberts economics since the project qualifies for a 30% tax credit.

The following assumptions and data were utilized for computations:

- AO (Annual O&M): $28,000 for year 1, increasing 3% per annum for the life of the plant
- RV (Residual Value): $0. Plant assumed to have no value at the end of its life
- N (Plant Life)= 25 Years
- DR (Discount Rate):
  - i (Nominal) 3%
  - r (Real): 0.98% (Calculated via the Fischer equation, see section 5.4
- E(I) (Inflation Rate): 2% (Per U.S. government stated target rate for inflation)
- Project Cost = $3,430,000
  - With 30% Investment Tax Credit: $2,401,000
- Year 1 Actual Power Produced = 1,650MWh
- Annual Degradation: 0.8% per year (20% over life of Plant)

Project Cost Calculations:

The original contract price for the Camp Roberts project was $3,247,000 (See section 7.0, "Cost Assessment"). However, several additional and unexpected expenses were encountered during the project. During installation, additional expenses were incurred to cover the cost of an on-site archeologist to monitor all ground disturbing activities. There was also an additional $168,000 added to the original contract amount (contract amendment No. P00003) by the Department of Labor and the contract should have included per both the Davis Bacon Act and the Wage Determination CA29, modification 23, dated 04/08/2011. This should be accounted for in future installations. Consequently, the final contract price used for calculations is $3,430,000.

As a result of the above cost, and PV Peak Capacity (Installed) of the system at 998.4kW, the Camp Roberts demonstration cost is $3.44/W against a target of $3.2/W. As noted earlier, without the actual cost data for all PV Plant equipment from Belectric, it is difficult to determine if the actual plant cost was lessor morethan the calculated $3.44/W and whether the performance objective metric was achieved.

Operations and Maintenance costs for the first year of operations are $28,000 per State of California Agreement B0444. Beyond year 1, Belectric estimates the following cost increases for years 2 through 5, or an average increase of 3.65%:

- Year 2: 7.1%
- Year 3: 3.0%
- Year 4: 2.9%
- Year 5: 1.6%

During the 25 year life of the camp Roberts demonstration, O&M increases are expected to average 3%, and this estimate was used for all appropriate calculation purposes.

Using this 3% factor, the Fisher equation, and Present Value formula leads to the following:

- NPV O&M Costs, Nominal Discount Rate: $700,000.00
- NPV O&M Costs, Real Discount Rate: $896,848.39

Energy Calculation.

During the first year of plant operation, performance monitoring equipment captured ambient temperature, wind velocity, solar irradiance, and actual energy produced in 15-minute increments. From this information, total energy produced over the life of the plant can be accurately estimated.

Specifically, averaging the Year 1 raw OMS data provides the monthly performance for the Camp Roberts Solar Field as shown in Table 4.

Table 4: Performance by Month for Camp Roberts Solar Field

DATE	Ambient Temp Deg. C	Wind Velocity (m/s)	Solar Irradiance (Wh/m²)	Energy Produced (kWh)
Jul-12	21.17	1.79	213,076.59	155,134.00
Aug-12	22.76	1.91	223,587.22	133,614.00
Sep-12	20.55	1.65	182,385.35	159,430.30
Oct-12	16.63	1.11	134,714.06	133,384.10
Nov-12	11.66	0.72	89,315.43	95,083.20
Dec-12	8.02	0.73	66,660.95	65,385.90
Jan-13	8.11	0.63	92,936.52	104,518.30
Feb-13	8.49	0.83	106,049.44	111,162.00
Mar-13	12.85	1.24	160,389.27	147,841.30
Apr-13	15.76	2.03	212,277.54	179,860.20
May-13	18.21	2.52	232,584.20	178,950.30
Jun-13	20.95	2.17	241,594.63	170,954.30
Jul-13	22.20	1.91	245,688.33	170,790.10
TOTAL				**1,650,974.00**

Using Year-1 actual energy produced of 1,650,974 kWh, and 0.8% annual degradation factor for panel performance change, the total energy produced over the life of plant can be calculated and is 37,522,543kWh.

LCOE Calculation Results:

Using data and calculations from the above sections results in the following LCOE values:

a) $0.110/kWh assuming no tax credits and nominal interest rate
b) $ 0.115/kWh assuming no tax credits and real interest rate
c) $0.083/kWh assuming a 30% tax credit and nominal interest rate
d) $0.088/kWh assuming a 30% tax credits and real interest rate

Although the $3.44/W solar plant cost is higher than the project's performance objective, LCOE real-dollar costs of $0.115/kWh are essentially equivalent to the $0.110kWh target given first-year actual energy production, contract costs, and assumptions about real discount rates. Additionally, since Camp Roberts received a 30% investment tax credit for the project, LCOE as calculated in case d) above, applies. $0.088/kWh represents a LCOE value 20% less than the $0.110 blended cost of electricity from the utility provider.

Green House Gas Emissions:

The OMS (Online Monitoring System), which is Meteocontrol, has a web interface called Safer'Sun. Safer'Sun has the ability to calculate greenhouse emissions saved based on the factor 0.8845051215 kg/kWh. When used for calculations, the actual GHG emissions saved associated with this power plant was 783,420kg for the 1 year period measured.

Reliability:

Data from the OMS was used to determine if the demonstration met Nanosolar's reliability requirements. The price Nanosolar's customers pay is based on the expected performance of the system, which is modeled using PVSyst and based on flash test data of the panels Nanosolar ships to the customer. The PVSyst report derives an annual expected kWh production of the system accounting for numerous factors including weather variance, irradiance, soiling loss, panel characteristics, inverter loss, and shading. The data monitoring logs the performance of the system and Nanosolar can compare actual data to the expected energy yield of the system over a 12 month period. Nanosolar's R&D group conducted extensive lab experiments to understand degradation over time of Nanosolar's panels allowing Nanosolar to extrapolate the data over a 25 year period and show the energy yield for the life of the system.

In addition to panel degradation studies, Nanosolar's Product Development team ensured that solar plant components used in the manufacturing of panels, inverters, cables, and other BoS parts were chosen and tested to ensure 25 year life.

Analysis of OMS data during the first year of plant operations showed that availability was 98.4%. A detailed examination of the daily data comprising of the monthly averages in table 4 shows 6 days in August 2012, during which no energy production was recorded. Additionally, solar irradiance captured by the OMS appears low during one day in December 2012. Despite

this, total energy produced and recorded exceeded the energy predicted by PV-Watts and as described in the table below.

Photovoltaic Peak Capacity and Renewable energy Produced:

Table 5: Performance by Month vs. PVWatts Predicted Energy

DATE	Ambient Temp Deg. C	Wind Velocity (m/s)	Solar Irradiance (Wh/m²)	Energy Produced (kWh)	Predicted Energy, PV-Watts (kWh)
Jul-12	21.17	1.79	213,076.59	155,134.00	172,726
Aug-12	22.76	1.91	223,587.22	133,614.00	172,185
Sep-12	20.55	1.65	182,385.35	159,430.30	145234
Oct-12	16.63	1.11	134,714.06	133,384.10	126081
Nov-12	11.66	0.72	89,315.43	95,083.20	97404
Dec-12	8.02	0.73	66,660.95	65,385.90	81933
Jan-13	8.11	0.63	92,936.52	104,518.30	84632
Feb-13	8.49	0.83	106,049.44	111,162.00	97480
Mar-13	12.85	1.24	160,389.27	147,841.30	130042
Apr-13	15.76	2.03	212,277.54	179,860.20	150167
May-13	18.21	2.52	232,584.20	178,950.30	171897
Jun-13	20.95	2.17	241,594.63	170,954.30	167780
Jul-13	22.20	1.91	245,688.33	170,790.10	172726
TOTAL				**1,650,974.00**	**1,597,561.00**

During the first year of operations, the Camp Roberts solar plant produced and delivered 1,650MWh AC. Power delivered exceeded PV-Watts projected value of 1,597MWh by 3.34% and is in line with industry experience where the CA Solar Initiative calculator underestimates actual power generated by 5-10%. See table 5 above for a comparison of performance..

As mentioned in the section on Reliability above, daily production data included 6 days in August 2012, during which "no data" was recorded. It also included one day in December 2012, during which measured irradiance and power generated appeared to be low vs. irradiance statistics. Despite these events which reduced actual power produced (or recorded), annual solar plant performance exceeded PV-Watts expectations.

Site Maintenance:

Verification that the site maintenance is carried out according to the proposed schedule for the first year is the responsibility of the O&M contracting company, Belectric.. This was arranged by Nanosolar in conjunction with the ESTCP office. Belectric is anticipated to be the O&M company of record going forward, and arrangements will be managed by the federal government.

State of California Standard Agreement B0444 applies for the first year O&M. Beyond year 1, Belectric estimates the following cost increases for years 2 through 5, or an average increase of 3.65%:

Year 2: 7.1%
Year 3: 3.0%
Year 4: 2.9%
Year 5: 1.6%

During the 25 year life of the camp Roberts demonstration, O&M increases are expected to average 3%, and this estimate was used for all appropriate calculation purposes.

Statistical Methodologies

Normalizing Data:

To normalize the field data, power output of the panels is adjusted to Standard Test Conditions (STC). In normalizing the data, Nanosolar uses temperature coefficients to adjust the power output to what it would be if the temperature was at Standard Test Conditions (STC) defined as 1000 W/m^2 irradiance at 25 degrees C. R&D tests at Nanosolar show lower temperatures lead to higher panel voltage.

As a result of Nanosolar's decision to cease operations by October, 2013, complete normalization of data was not accomplished, although the non-normalized data provides results very close to those that would be computed using data normalized to STC.

Graphical Methodologies

Nanosolar used both bar charts and tables when presenting performance data. This allows Nanosolar to easily compare performance from Nanosolar's system with existing technologies and systems.

Modeling and Simulation

PVSyst:

PVSyst is an industry standard modeling program. It takes weather files and charts data over a period of time (interpolating irradiance and temperature) to derive an expected energy yield of the system. This software is very detailed and accounts for panel characteristics, angle of incidence (AOI), soiling loss, inverter loss, orientation of the panels, shading loss, Ohmic loss of the system, module mismatch loss, and module quality loss.

Meteonorm:

Meteonorm software creates weather files used by PVSyst. Typically, Meteonorm uses weather station data collected over many years to derive expected weather parameters (temperature and irradiance) that can be used with PVSyst to simulate how a PV system would perform. It uses interpolation to fill in data-gaps where weather stations may not be present.

Sensitivity Analysis

Nanosolar has datasheets to provide information on how irradiance and temperature affects panel performance. Normalizing the data to STC could have kept data from being effected by varying environmental changes, however normalization of the data was not completed due to Nanosolar's decision to cease operations by October, 2013.

Anecdotal Perspectives

The Operation & Maintenance (O&M) contract was awarded to Belectric as mentioned earlier in this section.

See customer satisfaction section 9.0 for additional Anecdotal Perspectives.

Industry Standards

STC Conditions:

STC stands for "Standard Test Conditions." It is a solar industry standard to rate panels. When Nanosolar states it is using 200W panels, this means the panels were found to produce about 200W in a lab under STC conditions. STC condition is defined as 1000 W/m2, 25 degrees C, and 1.5 AM (Air Mass).

These standards are generally used in photovoltaic panels. Nanosolar has documentation that manufactured panels adhere to the following list of standards:

- 61646 (thin film performance) and 61730 (all modules, safety)
- ISO 9488 Solar energy
- UL 1703
- UL 1741
- CE mark
- Electrical Safety Tester (EST) Series (EST-460, EST-22V, EST-22H, EST-170).

PTC Conditions:

PTC refers to PVUSA Test Conditions, which were developed to test and compare PV systems as part of the PVUSA (Photovoltaics for Utility Scale Applications) project. PTC conditions are defined as 1,000 Watts per square meter solar irradiance, 20 degrees C air temperature, and wind speed of 1 meter per second at 10 meters above ground level. PTC is an attempt at a more realistic measure of PV output because the test conditions better reflect "real-world" solar and climatic conditions, compared to the STC rating. For its technology used in the Camp Roberts demonstration, Nanosolar did not use PTC conditions for development, testing, or validation of its cells or modules.

Internal Validity

The following events affect measured performance and are both difficult to predict as well as control without incurring unreasonable preventative maintenance cost:

1) Soiling loss – O&M will involve cleaning the panels, but uncertainty regarding how much dust and dew will occur in the PV plant site remains. Typically Nanosolar assumes 2% soiling loss in the PVSyst simulation, but it could be more or less during operation in the field.
2) Monitoring/ Internet Connection – Whenever the internet is lost for a longer period of time than the data logger is capable of storing in its memory, the possibility of losing data exists. If the data logger malfunctions and is shutdown, this will also result in gaps in the data. However, the likelihood that the monitoring system will be down very long is

minimal. Additionally, 12 months' worth of data was collected so minimal gaps will not be material to the results of the demonstration project. Assumed in this is timely issue resolution if stakeholders note that monitoring is down. As an example of timely resolution of a monitoring issue, when the system went down on August 15, 2012, the issue was addressed in a timely manner.

External Validity

Validating future potential DoD sites will involve a developer performing the following work:

- Evaluating the land to determine whether it is viable for PV.
- Contacting the utility to determine if either a PPA or net metering is possible. Also seeing if there's a utility tie-in point nearby the site for interconnection.
- Researching on state and city policies that may prevent PV to be installed in that particular zone.
- Running a PVSyst report to determine how much energy yield would be expected from a PV system in that particular location and climate.
- Running a financial model to account for the price for energy and then comparing it to the IRR of the system over 25 years, ensuring the project makes financial sense.

Building Life-Cycle Cost Program

Building Life-Cycle Cost 5 (BLCC5), a software tool that created the MILCON ECIP analyses, was designed to evaluate the "relative cost effectiveness of alternative buildings and building-related systems or components." BLCC5's ECIP tool analyzes payback periods, IRR, and other financial metrics for environmental improvement projects. Its solar-related rebate and incentive tools are largely manual and not as developed as the SAM tool, but it has a strong use precedent in the Federal Government.

7.0 COST ASSESSMENT

For this demonstration project, cost tracking was very important. Table 6 represents the estimated cost from Belectric as part of the proposal as follows:

Table 6: Belectric Hardware and Installation Cost (Estimated)

Item	Cost ($)
Labor	347,780
Indirect Charge 1 (Direct Labor Overhead)	39,299
Major Equipment	2,300,000
Materials, Supplies, Consumables	150,000
Indirect Charge 2 (G&A)	255,337
Fixed Fee (Belectric Margin)	154,584
TOTAL	**3,247,000**

This chart did not anticipate the Davis/Bacon requirement which added $168K to the contract for labor rates and brought the contract total to $3,430,000. Additionally, as mentioned earlier, comparison of estimated and actual costs was not possible after 1 year of plant operation due to lack of data from Belectric.

7.1 COST MODEL

Table 7: Cost Model for Camp Roberts Solar Plant

Cost Element	Data Tracked During the Demonstration	Estimated Costs
Hardware capital costs	Estimates made based on component costs for demonstration	$2,300,000 (includes 4998 solar panels, a 1 MW inverter and all associated BoS (racks, etc.)
Installation costs	Labor and material required to install	$555,079 including direct & indirect labor as well as contract addendum of $168K.
Consumables	Estimates based on rate of consumable use during the field demonstration	$150,000 including misc. materials
Energy Generation	Energy Generated by system during field demonstration	1,650,974 kWh AC
Maintenance	• Frequency of required maintenance • Labor and material per maintenance action	$28,000/year for 1st year including inverter PM, grass & vegetation control, and module washing, etc.
Hardware lifetime	Estimate based on components degradation during demonstration	25 years.
Operator training	Estimate of training costs	N/A (very minimal)

7.2 COST DRIVERS

The price of solar panels dropped dramatically since the demonstration project proposal was first submitted in August 2010. This industry-wide solar pricing drop had a very detrimental effect on solar panel manufacturers like Nanosolar. Many companies had to close operations. Going forward, a renewed focus in the US on specialty applications such as BIPV (Building Integrated Photovoltaic) and related applications is required to allow for higher margins for panels and to ensure U.S.-based solar panel providers continue to be available to the government.

7.3 COST ANALYSIS AND COMPARISON

Although Nanosolar did not have access to the final cost numbers from Belectric, calculated LCOE numbers presented earlier provide a clear indication that the project performed well.

8.0 IMPLEMENTATION ISSUES

There were some issues with the project that are worthy of mention:

1. Gaps in data: there were 6 days in August 2012, with no data and one day in November 2012, exhibiting low power generation compared to other days of similar irradiance. The lesson is that data monitoring pays for itself by quickly identifying issues that need to be corrected for maintaining the maximum possible incentive dollar amount. There were also a few days in May 2013 that recorded no data for local temperature. This was likely due to a bad sensoronce addressed, thedata recording returned to normal.
2. There were nine panels that experienced shattered glass failures during the first few months of operations. These panels were replaced in November, 2012, with no further incidents. The O&M provider also has a few (87 estimated) extra panels for future occurrences if needed. Additionally, it would be possible to replace an entire string if there are a greater number of failures over time as long as the electrical specifications were kept within the tolerance of the inverter. An example of a frameless panel can be found @ Lumos Solar.com.
3. Belectric was slow to implement the O&M contract and the first service not completed until 6 months after the system was tied to the PG&E grid in May 2012. The NAVFAC technical program office will continue to monitor vendor performance going forward. At the end of the contract period, an additional 4 panels were found to be cracked during a visual inspection. These panels are scheduled to be replaced during the current month (September 2013).
4. There was no official LCOE report done due to the planned shutdown of Nanosolar in October 2013. This report calculates a best estimate that the program met the original LCOE goals.
5. Panel and BoS costs continue to decrease with rapid standardization and commoditization of components.
    a. Panels have become a commodity with typical selling price in the $0.60-$0.70 range. Pricing is still slowly declining as of September 2013. Many industry experts expect that pricing will completely stabilize by 2015.
    b. Inverter pricing is also dropping and Nanosolar expects these components will soon be a commodity like panels. It is predicted that the inverter will need to be replaced in year 15 at a future cost likely to be significantly lower that today's costs based on industry trends.
6. Labor is a significant opportunity for cost reduction and may be enabled by investment in simplifying construction and installation processes by improving racking.
    a. Nanosolar's expects the next areas to attack from a cost perspective are the racking and other BoS components, as well as the soft costs. It is clear to the author that the installed price of utility scale solar will be below $2/watt in the immediate future. This is a testament to how quickly the goals of this project—first proposed in 2010—became a reality, and at a rate far faster than envisioned.
7. During installation, there were additional expenses required to cover the cost of an archeologist to be present for all ground disturbing activities as the area was thought to

have possible Native American artifacts. This was a onetime occurrence that would not affect most future projects.

8. During installation, an additional $168,000 was added to the contract (contract amendment No. P00003) by the Department of Labor because the original contract should have included the Davis Bacon Act as well as Wage Determination CA29, modification 23, dated 04/08/2011. This should be accounted for in future installations.

9.0 CUSTOMER SATISFACTION

Telephone and in-person, informal interviews with Camp Roberts stakeholders indicate that customer satisfaction with the technology demonstration project is "High" using a scale of:

- Very High
- High
- Average
- Fair
- Poor

While this evaluation is subjective, the primary reasons for this customer satisfaction rating include positive assessments and/or perception of system cost, greenhouse gas emission savings, percent system uptime, energy yield, and ease of ease of operations and maintenance. This report was not available in whole or in part to interviewees during customer satisfaction discussions.

Additionally and for future projects, Nanosolar recommends that customer satisfaction interviews and surveys occur on a quarterly basis during the first year of power plant operation. The Camp Roberts project has shown that today's highly mobile workforce makes assessing customer satisfaction challenging as participants move on to new roles and endeavors. As an example, only five stakeholders associated with the project were available for interviews after the power plant had been in operation for one year.

Despite the above, input from stakeholders and customers indicates that the demonstration project satisfied their needs and expectations to a "High" degree.

9.1 FUTURE SOLAR PV POWER PLANT IMPROVEMENT OPPORTUNITIES

During customer satisfaction discussions and interviews, several improvement opportunities were identified for future projects. Key inputs are captured below:

- During system construction, panel should be mounted higher from the ground for easier maintenance and to prevent damage while the power plant is in operation. Mounting the front lip of the panel at 48 inches versus the systems 24 inches could accommodate this need.
- Operations and maintenance cost reductions could be achieve by modifying the system to allow use of livestock (e.g. sheep) to prevent buildup of grass and weeds under and around panels.
- Design teams should consider variations in panel mounting angle and this – direction to optimize energy yield for peak summer loads when the solar PV power plant offsets expensive utility electricity cost.
- Primary drivers of Balance of System costs are changing. Panels are becoming commodity items, and inverter technology is moving to commodity rapidly. Consequently, construction costs and other labor driven costs are becoming dominant and efforts should

be taken to decrease time and costs associated with construction and maintenance phases of future projects.

- The process by which stakeholders could review real-time energy production could be clearer.

REFERENCES

BELECTRIC. Web. Nov.-Dec. 2011. <http://www.belectric.com/en/home/>.

"Camp Roberts." *Calguard.ca.gov*. California National Guard. Web. 13 Nov. 2011. <http://www.calguard.ca.gov/CpRbts/Pages/default.aspx>.

"Camp Roberts." *GlobalSecurity.org - Reliable Security Information*. Web. 13 Nov. 2011. <http://www.globalsecurity.org/military/facility/camp-roberts.htm>.

"CLCA Columbia University." *Clca.columbia.edu – Center for Life Cycle Analysis.* Web. 9 Sept. 2010. <http://www.clca.columbia.edu/3DP.1.3_Fthenakis_Valencia_2010.pdf>.

"CPUC." Cpuc.ga.gov – California Public Utilities Commission. Web. 5 Jan. 2012. <www.cpuc.ca.gov/cfaqs/howhighiscaliforniaselectricitydemandandwheredoesthepowercomefrom.htm>.

"EGRID." *EPA*. Environmental Protection Agency. Web. 9 Apr. 2012. http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

"EPA." *Epa.gov – Clean Energy*. Web. 1 Nov. 2011. <http://epa.gov/cleanenergy/energy-resources/refs.html>.

Executive Order 13514. Rep. 8 Oct. 2009. Web. 13 Nov. 2011. <http://www.ntis.gov/pdf/EO13514.pdf>.

"Installed Cost of Solar Photovoltaic Systems in U.S. Declined Significantly in 2010 and 2011." *ScienceDaily*. ScienceDaily, 15 Sept. 2011. Web. 11 Apr. 2012. http://www.sciencedaily.com/releases/2011/09/110915163959.htm

McCalmont Engineering. Web. Nov.-Dec. 2011. <http://www.mccalmontengineering.com/>.

Meteocontrol.com. Web. 14 Nov. 2011. <http://www.meteocontrol.com>.

Nanosolar.com. Web. Nov.-Dec. 2011. <http://www.nanosolar.com/>.

"Record Cost Reductions in US Solar Power Spurs Growth, in Green Jobs Too."*CleanTechnica*. 16 Sept. 2011. Web. 11 Apr. 2012. http://cleantechnica.com/2011/09/16/record-cost-reductions-in-us-solar-power-spurs-growth-in-green-jobs-too/

Strategic Environmental Research and Development Program, Environmental Security Technology Certification Program. Web. Nov.-Dec. 2011. <http://www.serdp.org/>.

"Sustainability, DENIX." *DENIX.osd.mil*. Web. 13 Nov. 2011. <http://www.denix.osd.mil/sustainability/upload/DoD-SSPP-FY17-FINAL_Oct17.pdf>.

APPENDICES

Appendix A: Points of Contact

Point of Contact	Organization	Phone & E-mail	Role in Project
John Bender	Nanosolar	(408) 718-7613 John.bender@Nanosolar.com	Principal Investigator
Merc Martinelli	Ex-Nanosolar	(408) 888-4784 mercm@cruzio.com	Co-author
Barbara A. Nuismer	Camp Roberts	(805) 391-0302 Barbara.a.nuismer.mil@mail.mil	Camp Roberts Commander
Sean P. Byrne	Camp Roberts	(619) 854-1948 Sean.p.byrne.mil@mail.mil	Camp Roberts DPW
John Graham	Belectric	(510) 896-3335 John.graham@belectric-usa.com	Director of Construction
Darlene McCalmont	McCalmont Engineering	(408) 871-9600 darlenemccalmont@mccalmont.net	Reporting Consultant
Vern Novstrup	NAVFAC	(805) 701-9181 vern.novstrup@navy.mil	PE CEM Environmental Engineering

Apendix B: Nanosolar Utility Panel Spec from "As Built" Documentation

nanosolar

Nanosolar Utility Panel

Performance

Maximum Rated Power	$180W_p - 240W_p$
Tolerance[1]	+/- 5%
Limited Warranty[1]	5 years material & workmanship 90% nominal power output for first 10 years 80% nominal power output for first 25 years

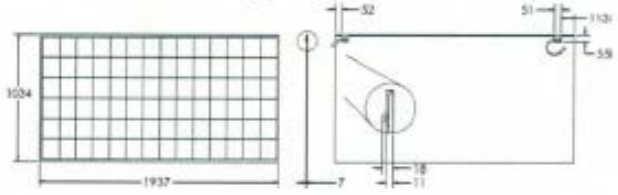
Mechanical Characteristics

Dimensions	Length: 1937 mm (76 in) Width: 1034 mm (41 in) Height: 7 mm (0.28 in)
Weight	34.7 kg (76.3 lbs)
Construction	Frameless glass/glass laminate 3 mm tempered solar glass front 3 mm tempered glass back
Solar Cells	84 MWT CIGS cells in series
Cell Layout	6 cells per string 14 strings per module
Output Cables	80 mm cable (positive) 300 mm cable (negative)
Output Terminal	MC3 compatible
Mounting Systems	4 clamps for 2400 Pa load Additional 2 rails for 5400 Pa

Shipping Quantities

Per Pallet	60
Per 20-foot ISO Container	600

Mechanical Drawing



Electrical Characteristics at STC[2]

Rated Power (W_p)	180	190	200	210	220	230	240
V_{MPP} (V)	34.3	35.5	36.6	37.7	39.5	40.5	42.2
I_{MPP} (A)	5.4	5.5	5.6	5.7	5.7	5.8	5.8
V_{OC} (V)	46.0	46.9	47.8	48.7	49.6	50.5	51.4
I_{SC} (A)	6.6	6.7	6.7	6.7	6.7	6.7	6.7
Max System Voltage	1500V						
Max Series Circuit Fuse	25A						
Nominal Operating Cell Temperature	47°C						

Electrical Characteristics at NOCT[3]

Rated Power (W_p)	180	190	200	210	220	230	240
V_{MPP} (V)	30.1	30.9	32.3	33.4	34.6	36.0	37.3
I_{MPP} (A)	4.2	4.4	4.5	4.5	4.6	4.7	4.8
V_{OC} (V)	41.6	42.5	43.8	44.5	45.3	46.6	47.4
I_{SC} (A)	5.3	5.4	5.4	5.4	5.4	5.4	5.4

Qualifying Test Conditions

Temperature Cycling	-40°C to +85°C, 200 cycles
Damp Heat	85% RH, 85°C, 1000 hr
Static Load Front and Back	2400 Pa (50 psf)
Hailstone Impact	25 mm diameter at 23 m/s

Quality and Safety

- IEC 61646 & 61730
- UL 1703, Fire Resistance Class A
- TUV Safety Class II up to 1500VDC

[1] Contact Nanosolar for full warranty terms
[2] Standard Test Conditions (STC): 1000 W/m², 25°C, AM1.5G
[3] NOCT Test Conditions: 800 W/m², ambient 20°C, Wind ≤1m/s

www.nanosolar.com

NSC-001 Rev 9 (4/2011)

Appendix C: eGRID2010 Version 1.1

eGRID2010 Version 1.1 Year 2007 GHG Annual Output Emission Rates

Annual total output emission rates for greenhouse gases (GHGs) can be used as default factors for estimating GHG emissions from electricity use when developing a carbon footprint or emission inventory. Annual non-baseload output emission rates should not be used for those purposes, but can be used to estimate GHG emissions reductions from reductions in electricity use.

eGRID subregion acronym	eGRID subregion name	Annual total output emission rates			Annual non-baseload output emission rates		
		Carbon dioxide (CO_2) (lb/MWh)	Methane (CH_4) (lb/GWh)	Nitrous oxide (N_2O) (lb/GWh)	Carbon dioxide (CO_2) (lb/MWh)	Methane (CH_4) (lb/GWh)	Nitrous oxide (N_2O) (lb/GWh)
AKGD	ASCC Alaska Grid	1,284.72	27.11	7.44	1,363.19	34.99	6.95
AKMS	ASCC Miscellaneous	535.73	22.65	4.48	1,462.30	61.68	12.18
AZNM	WECC Southwest	1,252.61	18.80	16.57	1,211.84	20.56	9.31
CAMX	WECC California	681.01	28.29	6.23	1,045.30	39.42	4.74
ERCT	ERCOT All	1,252.57	17.76	13.99	1,096.19	19.69	5.63
FRCC	FRCC All	1,220.11	41.19	15.25	1,286.41	43.40	11.50
HIMS	HICC Miscellaneous	1,343.82	135.15	21.71	1,645.57	122.94	21.33
HIOA	HICC Oahu	1,620.76	91.05	20.89	1,630.89	106.18	18.52
MROE	MRO East	1,692.32	28.79	29.05	1,905.18	35.25	29.98
MROW	MRO West	1,722.67	28.97	29.19	1,988.69	53.59	32.98
NEWE	NPCC New England	827.95	76.98	15.20	1,204.91	60.69	13.41
NWPP	WECC Northwest	858.79	16.34	13.64	1,279.58	43.31	15.75
NYCW	NPCC NYC/Westchester	704.80	26.22	3.35	1,234.06	37.65	4.88
NYLI	NPCC Long Island	1,418.74	90.50	13.10	1,397.80	44.08	6.99
NYUP	NPCC Upstate NY	683.27	17.41	9.90	1,384.20	31.55	16.19
RFCE	RFC East	1,059.32	27.40	17.03	1,671.96	33.29	22.19
RFCM	RFC Michigan	1,651.11	32.55	27.79	1,803.64	32.09	27.33
RFCW	RFC West	1,551.52	18.37	25.93	1,982.05	24.30	31.48
RMPA	WECC Rockies	1,906.06	23.63	28.89	1,554.38	23.17	16.45
SPNO	SPP North	1,798.71	21.22	29.20	1,958.22	25.40	27.75
SPSO	SPP South	1,624.03	24.52	22.42	1,435.24	25.03	13.14
SRMV	SERC Mississippi Valley	1,004.10	21.80	11.15	1,171.05	28.25	6.91
SRMW	SERC Midwest	1,779.27	20.57	29.60	1,945.66	24.02	29.69
SRSO	SERC South	1,495.47	23.64	24.57	1,551.05	28.50	21.69
SRTV	SERC Tennessee Valley	1,540.85	19.87	25.48	1,917.25	25.98	30.05
SRVC	SERC Virginia/Carolina	1,118.41	22.26	19.08	1,661.11	38.01	24.51
U.S.		**1,293.05**	**25.07**	**19.64**	**1,520.21**	**32.23**	**18.41**

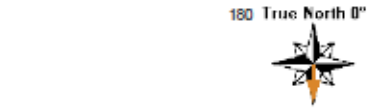
This is a representational map; many of the boundaries shown on this map are approximate because they are based on companies, not on strictly geographical boundaries.

Appendix D: CA Solar Initiative Projection for Camp Roberts

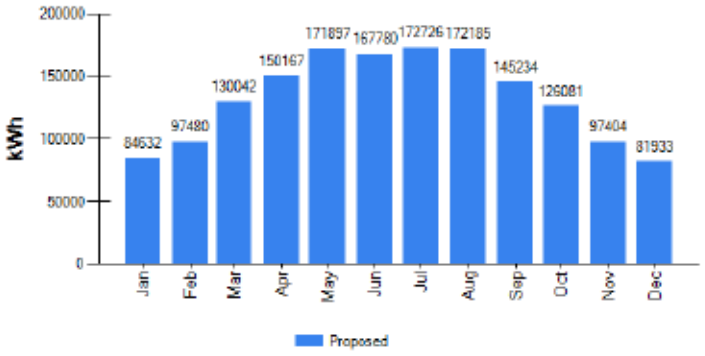
Incentive Calculator - CSI Standard PV

The CSI-EPBB calculator is a tool available to participants of the CSI Program to determine the EPBB Design Factor and calculate an appropriate incentive level based on a reasonable expectation of performance for an individual system. The CSI-EPBB Calculator has also been created for consumer's to educate themselves on the differences of solar system design and how changes to the PV system's specifications will produce different kilowatt hour results over the course of a year. Please be aware that actual performance of an installed PV system is based on numerous factors, including some factors that may not be considered in the CSI-EPBB Calculator. While this calculator relies on industry-standard assumptions, and is driven by NREL's PV Watts v. 2 calculator, there may be other factors that affect the output of your PV System.

	Proposed
Site Specifications:	
Project Name	Camp Roberts - Nanosolar
ZIP Code	93451
City	San Miguel
Utility	PG&E
Customer Type	Government/Non-Profit
Incentive Type	PBI
PV System Specifications:	
PV Module	Nanosolar:Nanosolar Utility Panel 200W 200.0W STC, 175.0W PTC
Number of Modules	5000
Mounting Method	>6" average standoff
DC Rating (kW STC)	1000.0000
DC Rating (kW PTC)	875.0000
Inverter	SatCon Technology:PVS-500 (MVT)
Number of Inverters	2
Inverter Efficiency (%)	95.50 %
Shading	Minimal Shading
Tracking	Fixed
Array Tilt (degrees)	20
Array Azimuth (degrees)	180 True North 0°



Estimated Monthly Production



	Proposed
Results	
Annual kWh	1,597,559
Summer Months	May-October
Summer kWh	955,902
CEC-AC Rating	**835.625 kW**
Capacity Factor[1]	21.824%
Prevailing Capacity Factor[2]	20.000%
Design Factor[3]	**109.120%**
Eligible Annual kWh[4]	**1,597,559**
Incentive Rate	**$0.114/kWh**
Incentive[5]	**$310,609**
	Please be aware that PG&E has received enough non-residential projects to move into Step 10 (once all projects are reviewed and reserved). The total capacity under review is 90.68 MW and the total capacity available in Step 9 is 41.43. It is very likely that your project will receive funding in Step 10 ($0.09/kWh).
Report Generated on	2/17/2012 11:10:51 AM

Notes:

1. **Capacity Factor**: This is the estimated annual output of the proposed system divided by 8760 times the CEC-AC rating.
2. **Prevailing Capacity Factor**: This is 18% during incentive steps 2 and 3 and 20% during incentive steps 4 through 10.
3. **Design Factor**: This is the ratio of the Capacity Factor and the Prevailing Capacity Factor.
4. **Eligible Annual kWh**: For systems greater than 1MW (CEC-AC Rating), this is the prorated estimated annual output of the proposed system.
5. **Incentive**: This is the estimated total incentive for the proposed system, and is calculated as the estimated eligible annual output times the incentive rate times 5 years. The incentive paid will be based on the actual production of the installed system.
   Please be aware that the final CSI incentive rate that is reserved for you will be determined by your CSI Program Administrator at the time your reservation request (RR) application is approved, and may be lower than the current incentive rate shown in the CSI Statewide Trigger Point Tracker. Please note that final incentive amounts are subject to change based upon the configuration of the as-built system. (Per the CSI Handbook, no projects or applications are reserved CSI funding until all required information has been submitted and approved in writing by the Program Administrator.)
6. As of 8/10/07, the CSI-EPBB calculator performs rounding as follows:
   - Estimated kWh production is rounded to the kWh
   - CEC-AC rating is rounded to the watt
   - Capacity factor is rounded to 5 significant digits
   - Design factor is rounded to 5 significant digits

Appendix E: NOAA Solar Calculator for Camp Roberts

NOAA Solar Calculator

Find Sunrise, Sunset, Solar Noon and Solar Position for Any Place on Earth

Show: ○World Cities ◉U.S. Cities ○GMD Observ.'s ○GMD Data Sites ○SurfRad

Click one of the small pins near (and in the same time zone as) your desired location. Use the control on the left side of the map to zoom in or out. Place the large pin in the exact desired location. You can use the Save button to have your computer remember the current location for next time. Check the DST check box if Daylight Saving Time is in effect for your site.

Location:	Lat 35.794529	Lng -120.7337808	Time Zone -6	DST? ☐	Save

Date:	Day 21	Mon Dec	Yr 2013	Local Time:	14 : 01 : 00 ☐PM

Equation of Time (minutes):	Solar Declination (in °):	Apparent Sunrise:	Solar Noon:	Apparent Sunset:	Az/El (in °) at Local Time:	
1.65	-23.44	09:09	14:01:17	18:53	179.92	30.8
Show on map:		Sunrise☑		Sunset☑	Local Time☑	

Appendix F: Customer Satisfaction Survey

Overall System Performance

1	The Nanosolar demonstration solar power plant successfully met objectives through its first year of operation, namely that DoD military installations throughout the U.S. can benefit from competitive electricity costs through on-site, distributed solar generation.
2	System Economics (LCOE) of $3.2/W solar power plant cost (11c/kWh real dollar LCOE) was achieved
3	Reliability / Uptime of the 1.0MW Camp Roberts solar system met expectations
4	Photovoltaic Peak Capacity (Power Delivered) matched estimates with less than or equal to 3% degradation of power peak delivered, normalized for STC.
5	Site maintenance during the first year of operations met expectations
6	If you have other overall system performance feedback, please enter in the Comments section

Design & Development Phase

7	Facility/Site Selection, permitting, and regulations compliance met expectations
8	System design, including panels, inverters, racking, cabling, and other Balance of System (BOS) components met expectations
9	The web-based performance monitoring system with security to measure and analyze system performance at 15-minute increments and help calculate the LCOE, along with video of he installation met expectations
10	The project published standard designs for the DoD for 1MW, 3MW and 5MW distributed generation, solar power plants to expected levels of thoroughness
11	Appropriate design reviews and phase checkpoint meetings were conducted, and stakeholder input considered in future iterations of the project design
12	If you have other comments, suggestions, or improvements regarding what should be done on future projects during the Design & Development Phase, please enter in the Comments section

Project Construction Phase

13	Site preparation and layout activities met expectations
14	Ordering, delivery, and installation of modules, racking, inverters and other project materials was timely, met schedule requirements, and was installed in a quality fashion

15	Pre-system energizing testing and calibration occurred in a thorough fashion, eliminating power plant start-up problems
16	Interface with PG&E, City, and other regulatory agencies was handled in a thorough, efficient, compliant fashion
17	Post-construction, the site was left in a clean state
18	Sufficient Construction progress reviews occurred, and feedback incorporated into the project
19	Construction phase work was completed in a safe, compliant fashion
20	If you have other comments, suggestions, or improvements regarding what should be done on future projects during the Project Construction Phase, please enter in the Comments section
	Operations & Maintenance
21	Maintenance and testing of power distribution equipment, visual inspections and module replacement if needed has occurred on a timely basis
22	Spare components, inverter parts, extra fuses, specialized tools & equipment is available as needed
23	Daily monitoring, reporting, administration and hosting is working to expectation
24	Vegetation control, grounds maintenance, and panel washing occurs as needed
25	If you have other comments, suggestions, or improvements regarding what should be done on future projects during the Project Construction Phase, please enter in the Comments section
	Other
26	If you have other comments, suggestions, or improvements regarding what should be done on future projects, please enter in the Comments section

Appendix G: PG&E Net Metering Statement

Pacific Gas and Electric Company

PACIFIC GAS AND ELECTRIC COMPANY
NET ENERGY METERING ELECTRIC STATEMENT
THIS IS NOT A BILL
Service Dates: August 15,2012 to September 16,2012
True-up period from May 2012 to Apr 2013

CALIFORNIA NATIONAL GUARD
HWY 101
PASO ROBLES, CA. 93446

Rate Schedule: E20P/NEMEXPM
Account ID: 1772622118
Service ID: 1772622005

CURRENT MONTH'S NON-ENERGY CHARGE: **$32,778.86***
*This amount is reflected on your regular monthly blue bill and includes the following components: Transmission $4,727.19, Distribution $14,994.77 and Generation $13,056.90.

CURRENT MONTH'S ENERGY CHARGE:

TOTAL CHARGE: **$29,998.07**

$62,776.93

To determine the total amount you must pay this month, please add Cumulative Energy Charges of $116,125.14 to the "Total Amount Due" appearing on your blue bill statement. Please pay this total amount instead of the "Total Amount Due" on your blue bills. Your "Total Amount Due" may be negative.

ENERGY CHARGES/CREDITS

Current Month Energy Charge or Credit (-) **$29,998.07**

Cumulative Energy Charges or Credits (-) for the current true-up period: **$116,125.14**
This Cumulative Energy Charge does not reflect any payment you may have made.

Any credits you may have accumulated for net generation will be used to off-set any future energy charges within the current true-up period.

CURRENT MONTH METER INFORMATION:

CHANNEL ID	METER BADGE	PRIOR READ DATE	CURRENT READ DATE	PRIOR READ TIME	CURRENT READ TIME	USAGE (kWH)
BRJ04A	M08768	08/15/12	09/16/12	24:00	24:00	375,926
BRJ04C	M08768	08/15/12	09/16/12	24:00	24:00	-10,172
TOTAL						365,754

CURRENT MONTH RKVAH INFORMATION:

CHANNEL ID	METER BADGE	PRIOR READ DATE	CURRENT READ DATE	USAGE (RKVAH)
BRJ04B	M08768	08/15/12	09/16/12	335,121
TOTAL				335,121

CURRENT MONTH TOU DEMAND:

SEASON	TOU PERIOD	DEMAND CONSTANT	MAXIMUM DEMAND
Summer	Peak	.180	1,209
Summer	Part	.180	1,025
Summer	Off	.180	846

For inquiries about your Net Energy Metering bill, please contact the Solar Customer Service Center at 1-877-743-4112.
For all other inquiries, please call 1-800-743-5000.

Date Billed: 09/20/12
Biller: R4GI

Billing Point ID: 800008 9084

Pacific Gas and Electric Company

PACIFIC GAS AND ELECTRIC COMPANY
NET ENERGY METERING ELECTRIC STATEMENT
THIS IS NOT A BILL
Service Dates: August 15,2012 to September 16,2012
True-up period from May 2012 to Apr 2013

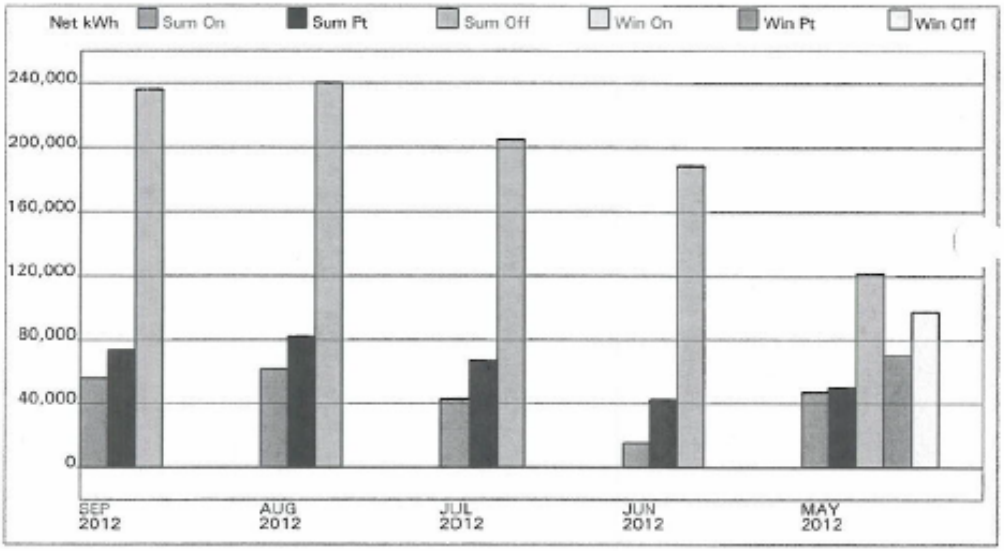
CALIFORNIA NATIONAL GUARD
HWY 101
PASO ROBLES, CA. 93446

Rate Schedule: E20P/NEMEXPM
Account ID: 1772622118
Service ID: 1772622005

ENERGY TRUE-UP HISTORY:

BILLING MONTH	BILL TO DATE	SUMMER ON	SUMMER PART	SUMMER OFF	WINTER PART	WINTER OFF	TOTAL ENERGY	ENERGY CHARGES /CREDITS
SEP 2012	09/16/12	55,765	73,634	236,355			365,754	$29,998.07
AUG 2012	08/15/12	61,687	81,860	240,369			383,916	$31,742.63
JUL 2012	07/17/12	42,767	66,590	205,363			314,720	$25,674.89
JUN 2012	06/17/12	15,283	42,407	188,655			246,345	$19,038.29
MAY 2012	05/17/12	46,894	49,605	121,473	70,154	97,154	385,280	$9,671.26
TOTALS							1,696,015	$116,125.14

**Energy Charges/Credits (-) include all energy related amounts and taxes.



Appendix H: LCOE Calculation Details

Present value of Operations and Maintenance, Camp Roberts

O&M Cost / Year for Life of Camp Roberts

Year	O&M Cost	Year	O&M Cost	Year	O&M Cost
1	$ 28,000.00	11	$ 37,629.66	$ 21.00	$ 50,571.11
2	$ 28,840.00	12	$ 38,758.55	$ 22.00	$ 52,088.25
3	$ 29,705.20	13	$ 39,921.30	$ 23.00	$ 53,650.90
4	$ 30,596.36	14	$ 41,118.94	$ 24.00	$ 55,260.42
5	$ 31,514.25	15	$ 42,352.51	$ 25.00	$ 56,918.23
6	$ 32,459.67	16	$ 43,623.09	**Total**	$ 1,020,859.40
7	$ 33,433.46	17	$ 44,931.78	**Average**	$ 40,834.38
8	$ 34,436.47	18	$ 46,279.73		
9	$ 35,469.56	19	$ 47,668.13		
10	$ 36,533.65	20	$ 49,098.17		

Real Discount Rate Calculation

Assumed Inflation Rate		2.00%
Calculated Real Discount Rate		0.98%
Fischer Equation		
Real Discount Rate = r = [(1+i)/1+E(I)] - 1		
where	i = Nominal Interest Rate	
	E(I) = Inflation Rate	

O&M Net Present Value Calculation

	Nominal NPV	Real NPV
Net Present Values	$ 700,000.00	$ 896,848.39

Energy Production Calculation

Energy Per Year, Calculated

Year	MWh	KWh	Year	MWh	KWh	Year	MWh	KWh
1	1650	1650000	11	1523	1522652	21	1405.133	1405133
2	1637	1636800	12	1510	1510471	22	1393.892	1393892
3	1624	1623706	13	1498	1498387	23	1382.741	1382741
4	1611	1610716	14	1486	1486400	24	1371.679	1371679
5	1598	1597830	15	1475	1474509	25	1360.705	1360705
6	1585	1585048	16	1463	1462713	**Total**	37522.54	37522543
7	1572	1572367	17	1451	1451011	**Average**	1500.902	1500902
8	1560	1559788	18	1439	1439403			
9	1547	1547310	19	1428	1427888			
10	1535	1534931	20	1416	1416465			

Assumptions

- Linear degradation 0.8% per annum, for a total life-of-project degradation of 20%.

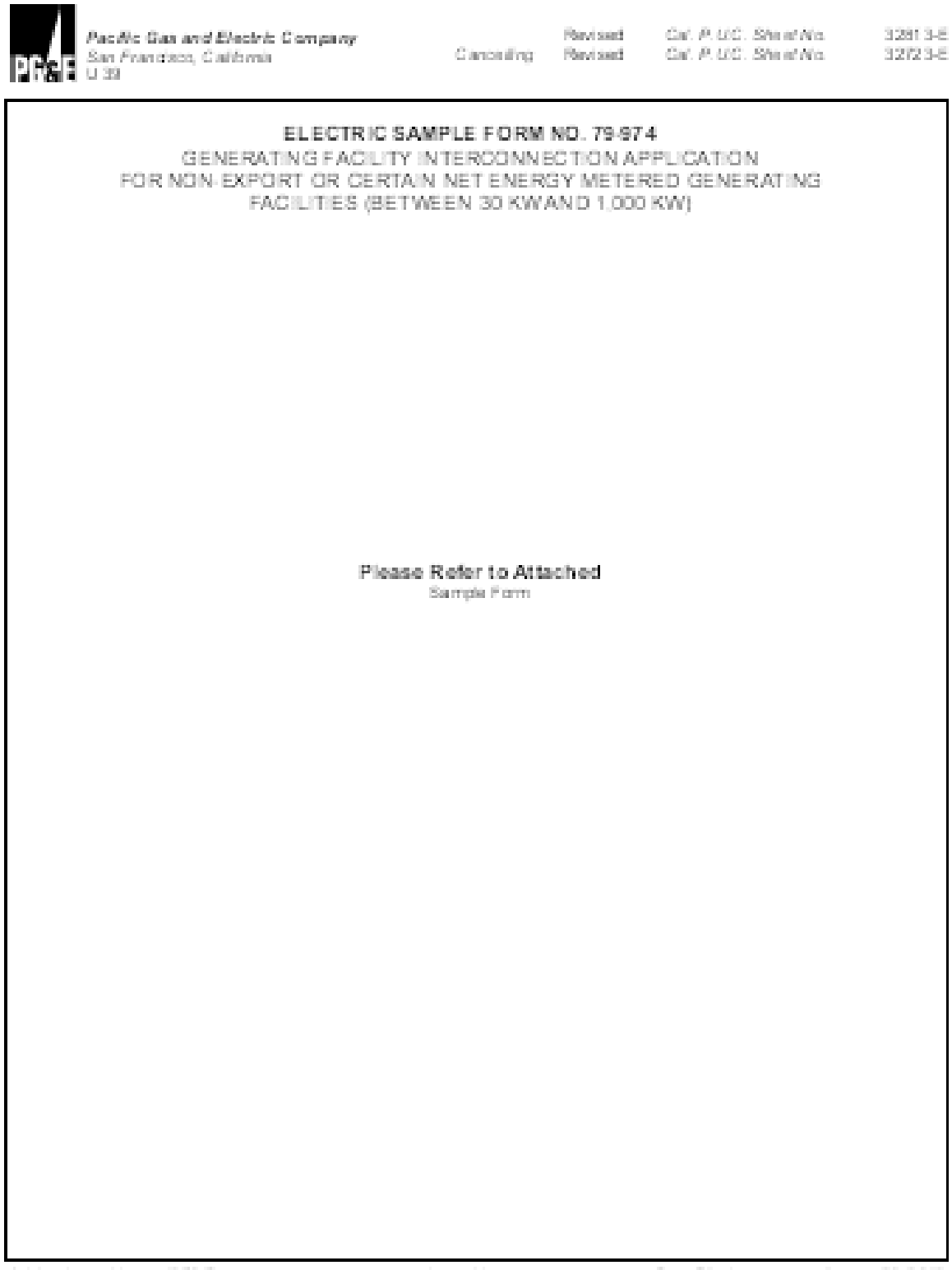
LCOE Calculation

Nominal Int Rate O&M Cost	$ 700,000.00		
Real Int Rate O&M Cost	$ 896,848.39		
Project Cost, No Tax Credit	$ 3,430,000.00		
Tax Credit	30%		
Project Cost, Tax Credit	$ 2,401,000.00		
Energy Produced	37522543		
LCOE No Tax Credit, Nominal Interest Rate on O&M			$ 0.1101
LCOE No Tax Credit, Real Interest Rate on O&M			$ 0.1153
LCOE Tax Credit, Nominal Interest Rate on O&M			$ 0.0826
LCOE Tax Credit, Real Interest Rate on O&M			$ 0.0879

The following assumptions and data were utilized for computations:

- AO (Annual O&M): $28,000 for year 1, increasing 3% per annum for the life of the plant
- RV (Residual Value): $0. Plant assumed to have no value at the end of its life
- N (Plant Life)= 25 Years
- DR (Discount Rate):
  - i (Nominal) 3%
  - r (Real): 0.98% (Calculated via the Fischer equation, see section 5.4)
- E(I) (Inflation Rate): 2% (Per U.S. government stated target rate for inflation)
- Project Cost = $3,430,000
  - With 30% Investment Tax Credit: $2,401,000

Appendix I: PG&E Form 79-974 "Generating Facility Interconnection Application"



Pacific Gas and Electric Company
San Francisco, California
U 39

Revised Cal. P.U.C. Sheet No. 32813-E
Cancelling Revised Cal. P.U.C. Sheet No. 32723-E

ELECTRIC SAMPLE FORM NO. 79-974

GENERATING FACILITY INTERCONNECTION APPLICATION
FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING
FACILITIES (BETWEEN 30 KW AND 1,000 KW)

Please Refer to Attached
Sample Form

Advice Letter No. 4270-E
Decision No.

1C7

Issued by
Brian K. Cherry
Vice President
Regulatory Relations

Date Filed August 28, 2013
Effective August 28, 2013
Resolution No.

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 KW and 1,000 KW)

Part I – Introduction and Overview

A. **Applicability:** This Generating Facility Interconnection Application (Application) is used to request the interconnection of a Non-Export or certain Net Energy Metered Generating Facility between 30 KW and 1,000 KW, to Pacific Gas and Electric Company's (PG&E) Distribution System (over which the California Public Utilities Commission (CPUC) has jurisdiction). Refer to PG&E's Rule 21 to determine the specific requirements for interconnecting a Generating Facility. Capitalized terms used in this Application, and not otherwise defined herein, shall have the same meanings as defined in PG&E's Rule 21 and Rule 1.

Except as noted in the next paragraph, this Application may be used for any Generating Facility to be operated by, or for, a Customer and/or Producer to supplement or serve part or all of its electric energy requirements that would otherwise be provided by PG&E, including distributed generation, cogeneration, emergency, backup, standby generation, and certain Net Energy Metered Generating Facilities. A simpler, shorter form is also available from PG&E for Net Energy Metering Customers with Solar and/or Wind Electric Generating Facilities less than 30kW (Form 79-1101). This form is available on PG&E's website at http://www.pge.com/pge. While Customers operating Generating Facilities isolated from PG&E's Distribution System are not obligated to enter into an Interconnection Agreement with PG&E, parts of this Application will still need to be completed to satisfy PG&E's notice requirements for operating an isolated Generating Facility as specified in the California Health and Safety Code Section 119065 (b).

This Application may not be used to apply for interconnecting Generating Facilities used to participate in transactions where all, or a portion of, the electrical output of the Generating Facility is scheduled with the California Independent System Operator. Such transactions may be subject to the jurisdiction of the Federal Energy Regulatory Commission (FERC) and require a different application available from PG&E.

This Application is not applicable for incentives and/or rebates offered by the Energy Resources Conservation and Development Commission (CEC) or the CPUC. Please contact those agencies directly or on their respective websites (www.energy.state.ca.us and www.cpuc.ca.gov).

Guidelines and Steps for Interconnection: This Application must be completed and sent to PG&E along with the additional information indicated in Part II, Section C below to initiate PG&E's interconnection review of the proposed Generating Facility. When applicable per Rule 21, a non-refundable $800 Interconnection Request fee shall be invoiced and must be paid by Applicant. Pursuant to PG&E's Rule 21, there may be additional study and other costs; see PG&E's Rule 21, Sections E.2.c and E.3, for more information regarding interconnection of a generator to PG&E's Distribution System.

This document is only an Application. Upon acceptance of the Generating Facilities, PG&E will prepare an Interconnection Agreement for execution by the Producer, the party that will be responsible for the Generating Facility. PG&E may also require an inspection and testing of the Generating Facility and installation of any related Interconnection Facilities prior to giving the Producer written authorization to operate in parallel. Unauthorized Parallel Operation may be dangerous and may result in injury to persons and/or may cause damage to equipment and/or property for which a Producer/Customer may be liable!

Please note, other approvals may need to be acquired, and/or other agreements may need to be formed with PG&E or regulatory agencies, such as the Air Quality Management Districts and local governmental building and planning commissions, prior to operating a Generating Facility. PG&E's authorization to operate in parallel does not satisfy the need for an Applicant to acquire such other approvals.

B. **Required Documents:** Each of the following documents are required to be submitted before this application will be processed. Drawings must conform to accepted engineering standards and must be legible. Electronic documents are preferred.

1. A Single-line drawing showing the electrical relationship and descriptions of the significant electrical components such as the primary switchgear, secondary switchboard, protective relays, transformers, generators, circuit breakers, with operating voltages, capacities, and protective functions of the Generating Facility, the Customer's loads, and the interconnection with PG&E's Distribution System. Please show the location of all required net generation electric output meter(s) and the A.C. manual operated disconnect switch on the single line drawing, when required.
2. Site plans and diagrams showing the physical relationship of the significant electrical components of the Generating Facility such as generators, transformers, primary switchgear/secondary switchboard, and control panels, the Customer's loads and the interconnection with PG&E's Distribution System. Please show the location of all required net generation electric output meter(s) and the A.C. manual operated disconnect switch on the site plans, when required.
3. If transformers are used to interconnect the Generating Facility with PG&E's Distribution System, please provide transformer nameplate information (voltages, capacity, winding arrangements, connections, impedance, at cetera).
4. If a transfer switch or scheme is used to interconnect the Generating Facility with PG&E Distribution System, please provide component descriptions, capacity ratings, and a technical description of how the transfer scheme is intended to operate.
5. If protective relays are used to control the interconnection, provide protection diagrams or elementary drawings showing relay wiring and connections, proposed relay settings, and a description of how the protection scheme is intended to function.

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 KW and 1,000 KW)

B. A non-refundable $800 Interconnection Request fee shall be invoiced and required, when applicable per Rule 21.

C. Application Instructions: Complete this application and enter this information into PG&E's web-based form. (PG&E strongly recommends preparing all information and materials before starting the online application.) The online web-based from can be found at:

http://www.pge.com/mybusiness/customerservice/nonpgeutility/generateownpower/distributedgeneration/generationrule21/

Questions concerning PG&E's Online Application process can be directed to the Electric Generation Interconnection Department at: rule21gen@pge.com.

Part II Selecting the Study Process[1]

Please check one:

- ☐ Fast Track Process.
- ☐ Detailed Study (not typical)
  - Will be either an Independent Study Process, Distribution Group Study Process or Transmission Cluster Study Process, dependent upon the Electrical Independence Tests.

Part III – Identifying the Generating Facility Location and Responsible Parties

Project Name:	*Date Received:*	*Generating Facility ID:*	*Application Expiration Date (Refer to Part III, Section E)*

(For PG&E Use Only)

A. Customer Electric Account Information (What electric service will the Generating Facility be interconnected for parallel operation with PG&E? For aggregated electric accounts (under NEMBIO, dairy operations only) provide the primary and all associated accounts/meter information).

Name shown on PG&E service account	Electric Service Agreement ID number	Electric Badge (Meter) Number

NOTE: Customer Electric account must match the customer's utility bill account information.

Meter Location Street Address	City	State	Zip

Part III Cont'd – Identifying the Generating Facility Location and Responsible Parties

[1] For selection of Study Process for Exporting Generating Facilities, please complete the Rule 21 Exporting Generating Facility Interconnection Request Form 79-1145.

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 KW and 1,000 KW)

Please check all that apply:

- ☐ A New Generating Facility Interconnection (at an existing service).
- ☐ Physical Changes to an Interconnected Generating Facility with previous approval by PG&E (adding PV panels, changing inverters/turbines or changing load and/or operations).
- ☐ A New Interconnection in conjunction with a new service.
  - An Application for Service must be completed. Additional fees may be required if a service or line extension is required (In accordance with PG&E Electric Rules 15 and 16). Please contact PG&E at 1-800-PGE-5000.
- ☐ An Interconnection under Direct Access (DA).
  - Customers applying for Interconnection who are served under Direct Access by an Electric Service Provider (ESP) must contact their ESP directly for information regarding the options available under their Direct Access contract.
- ☐ An Interconnection under Community Choice Aggregation Service (CCA Service).
  - Customers applying for Interconnection who are served under Community Choice Aggregation Service (CCA Service) by a Community Choice Aggregator (CCA) must contact their CCA directly for information regarding the options available under their CCA Service Program.
- ☐ An Interconnected non-exporting Generating Facility (load always exceeds generation).

Customer Electric Account Contact Information
(Who is the customer contact for progress updates and/or additional information?)

Contact Person	Company Name

Phone	Fax	E-mail

Mailing Address	City	State	Zip

B. Project Contact Information (Who is the project manager for this Generating Facility?)

Project Contact Person (Optional)	Company Name

Phone	Fax	E-mail

Mailing Address	City	State	Zip

B.1. Will the Generating Facility be owned by a (third) party other than the name appearing on the PG&E service account in A. above (please check)? _____ Yes _____No

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 KW and 1,000 KW)

Part III Cont'd – Identifying the Generating Facility Location and Responsible Parties

C.1. Customer-Generating Facility Interconnection Agreement (GFIA) or Customer Generation Agreement (CGA) (for 3rd Party Generator on Premises) Information (Please identify the party that will execute the applicable agreement). CGA is not applicable to Net Energy Metering (NEM) Applicants because PG&E and the Customer, not the 3rd Party if any, must enter into the Net Energy Metering Interconnection Agreement.

Company Name to be entered on GFIA/CGA	Legal Title of Host Facility to be entered on GFIA/CGA
Person Executing the GFIA/CGA	Title of Person Executing the GFIA/CGA

Mailing Address	Phone	E-Mail

C.2. 3rd Party Owner – GFIA Information (Please identify the Party, if known, that will execute the GFIA). This Section is not applicable to Net Energy Metering (NEM) Applicants because PG&E and the Customer, not the 3rd Party if any, must enter into the Net Energy Metering Interconnection Agreement.

Company Name to be entered on GFIA/CGA	Legal Title of Company to be entered on GFIA/CGA
Person Executing the GFIA	Title of Person Executing GFIA

Mailing Address	Phone	E-Mail

D. Operating Date (What date is this Generating Facility expected to begin operation?)

E. Expiration Date* (The date the status of this Application is changed to "withdrawn" by PG&E?)

* The information submitted in this Application will remain active and valid consistent with the timelines specified in Rule 21.f.

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 KW and 1,000 KW)

Part IV – Describing the Generating Facility and Host Customer's Electrical Facilities:

A. (MP&I)	Indicate the operating mode of the Generating Facility	operating mode options: __1 __2 __3 __4 (Choose one)

Instructions and Notes:

Choose from the following operating mode options:

1. Parallel Operation: The Generating Facility will interconnect and operate "in parallel" with PG&E's Distribution System for more than one (1) second.
2. Inadvertent Export: The Generating Facility will interconnect and operate, providing unscheduled and uncompensated export of real power for a duration exceeding two (2) seconds but fewer than sixty (60) seconds. The expected frequency of "inadvertent export" occurrences should be less than two occurrences per 24-hour period. Protective Functions, technical requirements and operational limitations are described in Rule 21, Section M, Appendix One.
3. Momentary Parallel Operation (MP): The Generating Facility will interconnect and operate on a "momentary parallel" basis with PG&E's Distribution System for a duration of one (1) second or less through transfer switches or operating schemes specifically designed and engineered for such operation.
4. Isolated Operation (I): The Generating Facility will be "isolated" and prevented from becoming interconnected with PG&E's Distribution System through a transfer switch or operating scheme specifically designed and engineered for such operation.

If the answer is operating mode option 1, "parallel operation," please supply all of the information requested for the Generating Facility. Be sure to supply adequate information including diagrams and written descriptions regarding the protective relays that will be used to detect faults or abnormal operating conditions on PG&E's Distribution System.

If the answer is operating mode option 2 or 3, "momentary parallel operation" or "inadvertent export," only questions A, E and F of this Part IV and questions A, B, E, F, I, L, M, N, and S of Part V need be answered. Be sure, however, to supply adequate information including diagrams and written descriptions regarding the switching device or scheme that will be used to limit the parallel operation period to one second or less. Please also describe the back up or protective device and controls that will trip the Generating Facility should the transfer switch or scheme not complete the transfer in one second or less.

If the answer is operating mode option 4, "isolated operation," only questions A, E, and F of this Part IV and questions A, B, F, and S of Part V need be answered. Be sure, however, to supply adequate information including diagrams and written descriptions regarding the isolating switching device or scheme that will be used to prevent the Generating Facility from operating in parallel with PG&E's Distribution System.

B. *Parallel Operation Applications Only*	If the Answer to Section A above was operating mode option 1, please indicate the type of agreement that is being requested with this Application. If operating mode option 2, 3 or 4 was selected, please skip to questions E and F. If Agreement options 2, 3, 5, 7, 8, or 9 to this Section B are chosen, please provide an estimate of the maximum kW the Generating Facility is expected to export to PG&E's Distribution System. If PG&E determines that the amount of power to be exported is significant in relation to the capacity available on its Distribution System, it may request additional information, including time of delivery or seasonal kW/kWh estimates.	agreement options: __1 __2 __3 __4 __5 __6 __7 __8 __9 (Choose all that apply) _____ Maximum kW

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 kW and 1000 kW)

Part IV Cont'd – Describing the Generating Facility and Host Customer's Electrical Facilities

Instructions and Notes

Sample agreements are available from PG&E for review. Choose from the following eight (8) agreement options:

Customer Owned Generating Facility (non-NEM)

1. A Generating Facility Interconnection Agreement that provides for parallel operation of the Generating Facility, but does not provide for exporting power to PG&E's Distribution System. This non-export agreement, however does allow the occasional and uncompensated export of energy to PG&E's Distribution System for less than 2 seconds in duration.
2. A Generating Facility Interconnection Export Addendum that provides for parallel operation of the Generating Facility and the occasional, continuous, non-compensated, export of generator facilities sized 2 MW or less to PG&E's Distribution System. Continuous export is export greater than 60 seconds in duration. This addendum must be executed in concert with Agreement 1.
3. A Generating Facility Interconnection Agreement that provides for parallel operation of the 3rd Party owned Generating Facility, but does not provide for exporting energy to PG&E's Distribution System. This agreement must be executed in addition to agreement 4.
4. A Customer Generation Agreement that defines the relationship between the Customer whose name appears on PG&E's electric service account. This agreement must be executed in addition to agreement 3.

Net Energy Metering Generating Facility

If you wish to have your Generating Facility participate on one of PG&E's Net Energy Metering tariffs, following your bi-directional meter installation, your meter and disconnect switch, when required, must be installed in a safe PG&E accessible location and remain unobstructed by plants, structures, locked gates or pets. Meter and disconnect switch access must be maintained at all times for your safety and PG&E's electrical system safety. Additionally, unencumbered access is required for meter reading, system maintenance, and operations. Any animals owned by the customer, for example pet dogs, should be kept clear from these areas to avoid hindering PG&E service personnel from completing their work.

Are there any meter access issues? Please check all that apply to avoid interconnection delays.

_____ Dog, or other animals at Residence

_____ Locked Gate

_____ Shrubs or Bushes

_____ Other (please explain) _____

5. A Net Energy Metering Agreement: Solar and Wind, that provides for parallel operation of the Generating Facility, and exporting energy to PG&E's Distribution System for credit under the terms of PG&E's Net Energy Metering tariffs pursuant to Public Utility Code Section 2827 for solar PV and/ or wind Generating Facilities greater than 30 kw to 1 MW or a Renewable Electrical Generation Facility (as defined in Schedule NEM) sized less than 1 MW, or any combination of these with a total size of no more than 1 MW per each applicable NEM tariff. This agreement also requires submittal of an expanded net energy metered supplemental application. This option is available only to eligible Generating Facilities as defined in PG&E's Net Energy Metering tariffs.
6. A Net Energy Metering Agreement: Fuel Cell, that provides for parallel operation of the Generating Facility, and exporting energy to PG&E's Distribution System for credit under the terms of PG&E's Net Energy Metering tariffs for fuel-cell Generating Facilities. This option is available only to eligible Generating Facilities as defined in PG&E's NEMFC tariff.
7. Multiple Tariff Generating Facility Agreement, that provides for the parallel operation of multiple Generating Facilities that are electrically connected behind the same Point of Common Coupling at least one of which is a Generating Facility eligible for service under NEM or other applicable Net Energy Metering tariffs, and may include a Generating Facility not eligible to receive service under a Net Energy Metering tariff.
8. Other, please describe: _____

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 kW and 1000 kW)

Part IV Cont'd – Describing the Generating Facility and Host Customer's Electrical Facilities

C. *Parallel Operation Applications Only*	If the answer to Section B above was agreement option 1 or 4, please indicate the protection option that will be used to prevent energy from being exported to PG&E's Distribution System. If protection option 3 to this Section C is selected, please provide the continuous current rating of the host Customer facility's service entrance equipment (service panel rating): If Protection Option 4 to this Section C is selected, please provide the minimum load of the host Customer facility:	Protection Option: __1 __2 __3 __4 __5 (Choose one) _____ Amps _____ kW

Instructions and Notes

Refer to PG&E's Rule 21, Sections F.1-3 and Section G, for additional information as to how to answer this question. If the Generating Facility will never export power to PG&E's Distribution System, a simpler, lower cost, protection scheme may be used to control the interface between the Generating Facility and PG&E's Distribution System. Choose from the following five options:

1. A reverse-power protection device will be installed to measure any export of power and trip the Generating Facility or open an intertie breaker to isolate the Generating Facility if limits are exceeded.
2. An under-power protection device will be installed to measure the inflow of power and trip or reduce the output of the Generating Facility if limits are not maintained.
3. The Generating Facility Interconnection Facility equipment has been certified as non-islanding and the incidental export of power will be limited by the design of the interconnection. If this option is to be used, the continuous ampere rating of the service entrance equipment (service panel rating) that is used by the host Customer facility must be stated in the space provided above.
4. The Gross Nameplate Rating of the Generating Facility will not exceed 50% of the host Customer facility's minimum electrical load over the past 12 months. If this option is to be used, the minimum load of the host Customer facility must be stated in the space provided above.
5. The Generating Facility completely offset their facility load by being (a) optimally sized to meet their peak demand with load following functionality on the Generator controls and (b) ensuring conditional (inadvertent) export of electric power from the Generation Facility to Distribution Provider's Distribution or Transmission System occurs no more frequently than twice in any 24 hour period and the exports are greater than 2 seconds but no more than more than 60 seconds.

   If this option is selected, you must also choose option 1 or 2.

Note: With the approval of PG&E, a Producer that wishes to retain the option to export power from a Generating Facility to PG&E's Distribution System may use a different protection scheme that provides for the detection of faults and other abnormal operating conditions.

D. *Parallel Operation Applications Only*	What is the maximum 3-phase fault current that will be contributed by the Generating Facility to a 3-phase fault at the Point of Common Coupling (PCC)? (If the Generating Facility is single phase in design, please provide the contribution for a line-to-line fault). Please indicate the short circuit interrupting rating of the host Customer facility's service panel:	_____ Amps _____ Amps

Instructions and Notes

Refer to PG&E's Rule 21, Section G, for significance and additional information. To determine this value, any transformers and/or significant lengths of interconnecting conductor used between each of the Generators (if there are more than one) that make up the

Part IV Cont'd - Describing the Generating Facility and Host Customer's Electrical Facilities:

Generating Facility and the POC must be taken into account. The details, impedance, and arrangement of such transformers and interconnecting conductors should be shown on the single-line diagram that is provided. Consult an electrical engineer or the equipment supplier if assistance is needed in answering this question.

It is expected that most Applicants will want to reserve the flexibility to operate any or all of their Generators in parallel. If the design of the proposed Generating Facility limits the amount of generation that may be interconnected at any time to PG&E's Distribution System, please describe the assumptions used in calculating the maximum fault current contribution value.

E. (MP&I)	Please indicate how this Generating Facility will be operated.	__1 __2 __3 __4 __5 __6 (Please choose all options that may apply.)

Choose from the following seven operation options:

1. Combined Heat and Power or Cogeneration – Where the operation of the Generating Facility will produce thermal energy for a process other than generating electricity.
2. Peak Shaving/Demand Management – Where the Generating Facility will be operated primarily to reduce electrical demands of the host Customer facility during PG&E's peak pricing periods.
3. Primary Power Source – Where the Generating Facility will be used as the primary source of electric power and power supplied by PG&E to the host Customer's loads will be required for supplemental, standby, or backup power purposes only.
4. Standby / Emergency / Backup – Where the Generating Facility will normally be operated only when PG&E's electric service is not available.
5. Net Energy Metering – Where the Generating Facility qualifies and receives service under PG&E's Net Energy Metering tariffs. For applicants for service under Schedule NEM as described in Part 3 B (7.) and (8.), a supplemental application (Form Number 79-998) is also required.
6. RES-BCT – Where the Generating Facility will be operated with no on-site electrical load (other than station load).
7. Multiple Tariff - Generating Facilities that have one or more Net Energy Metering (NEM) generator(s) and optionally a non-Net Energy Metering (non-NEM) generator(s). Check one of the following four options on the next sheet.

For Multiple Tariff Generating Facilities, check one of the following:

☐ New facility installing non-NEM generator(s) and NEM generator(s) at the same time.

☐ Existing facility with non-NEM generator(s) and planning to add NEM generator(s). Please provide data for the table below.

☐ Existing facility with NEM generator(s) and planning to add non-NEM generator(s). Please provide data for the table below.

☐ Existing facility with NEM generator(s) and planning to add NEM generator(s) under a different NEM tariff. Please provide data for the table below.

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 kW and 1000 kW)

Part IV Cont'd - Describing the Generating Facility and Host Customer's Electrical Facilities:

Instructions (From Part V)	Generator Information	Existing Generator Type	Existing Generator Type	New Generator Type	New Generator Type	Generating Facility Totals
#	Please indicate the number of each type of Generator being installed: (see instructions)					
A	Generator/Inverter Manufacturer					
B	Generator/Inverter Model					
C	Generator/Inverter software Version					
D	Is the Generator/Inverter certified	____ Yes ____ No	____ Yes ____ No	____ Yes ____ No	____ Yes ____ No	
E	Generator design	____ Synch ____ Induct. ____ Inverter	____ Synch ____ Induct. ____ Inverter	____ Synch ____ Induct. ____ Inverter	____ Synch ____ Induct. ____ Inverter	
F	Gross Nameplate Rating					
G	Operating Voltage					
H	Power Factor rating					
I	PF Adjustment Range					
J	Wiring Configuration					

Pacific Gas and Electric Company

GENERATING FACILITY INTERCONNECTION APPLICATION FOR NON-EXPORT OR CERTAIN NET ENERGY METERED GENERATING FACILITIES (Between 30 kW and 1000 kW)

Part IV Cont'd - Describing the Generating Facility and Host Customer's Electrical Facilities

Instructions (From Part V)	Generator Information	Existing Generator Type	Existing Generator Type	New Generator Type	New Generator Type
K (MP)	3-Phase Winding Configuration (Choose One)	__3 Wire Delta __3 Wire Wye __4 Wire Wye	__3 Wire Delta __3 Wire Wye __4 Wire Wye	__3 Wire Delta __3 Wire Wye __4 Wire Wye	__3 Wire Delta __3 Wire Wye __4 Wire Wye
L (MP)	Neutral Grounding System Used (Choose One)	__ Ungrounded __ Solidly Grounded __ Ground Resistor _____ Ohms	__ Ungrounded __ Solidly Grounded __ Ground Resistor _____ Ohms	__ Ungrounded __ Solidly Grounded __ Ground Resistor _____ Ohms	__ Ungrounded __ Solidly Grounded __ Ground Resistor _____ Ohms
M	*Synchronous Generators Only:* Synchronous Reactance: Transient Reactance: Subtransient Reactance:	_____ (Xd %) _____ (X'd %) _____ (X"d %)	_____ (Xd %) _____ (X'd %) _____ (X"d %)	_____ (Xd %) _____ (X'd %) _____ (X"d %)	_____ (Xd %) _____ (X'd %) _____ (X"d %)
N	*Induction Generators Only:* Locked Rotor Current: Stator Resistance: Stator Leakage Reactance: Rotor Resistance: Rotor Leakage Reactance:	_____ (Amps) _____(%) _____(%) _____(%) _____(%)	_____ (Amps) _____(%) _____(%) _____(%) _____(%)	_____ (Amps) _____(%) _____(%) _____(%) _____(%)	_____ (Amps) _____(%) _____(%) _____(%) _____(%)
O	Short Circuit Current Produced by Generator:	_____(Amps)	_____(Amps)	_____(Amps)	_____(Amps)
P	*For Generators that are Started as a "Motor" Only* 1. In-Rush Current: 2. Host Customer's Service Entrance Panel (Main Panel) Continuous Current Rating:	_____ (Amps) _____ (Amps)	_____ (Amps) _____ (Amps)	_____ (Amps) _____ (Amps)	_____ (Amps) _____ (Amps)
Q (MP&I)	Prime Mover Type: (Circle One)	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Part IV Cont'd - Describing the Generating Facility and Host Customer's Electrical Facilities

Instructions (From Part V)	Generator Information	Existing Generator Type	Existing Generator Type	New Generator Type	New Generator Type
R	AC Disconnect	Manufacturer Model # Rating (amps)	Manufacturer Model # Rating (amps)	Manufacturer Model # Rating (amps)	Manufacturer Model # Rating (amps)
S	Photovoltaic (PV) Panel	Manufacturer Model # Nameplate Rating (kw/unit) CEC Rating (kW/unit) Quantity of Panels Total Capacity (kW)	Manufacturer Model # Nameplate Rating (kw/unit) CEC Rating (kW/unit) Quantity of Panels Total Capacity (kW)	Manufacturer Model # Nameplate Rating (kw/unit) CEC Rating (kW/unit) Quantity of Panels Total Capacity (kW)	Manufacturer Model # Nameplate Rating (kw/unit) CEC Rating (kW/unit) Quantity of Panels Total Capacity (kW)
T	Lineside Tap	___ Yes ___ No	___ Yes ___ No	___ Yes ___ No	___ Yes ___ No

F. (MPSI)	Please indicate if Qualifying Facility (QF) Status will be obtained from the FERC for this Generating Facility.	__Yes __No

Instructions and Notes

Parties operating Generating Facilities (QF) complying with all of the requirements for qualification as either a small power production facility or cogeneration facility pursuant to the regulations of the FERC (18 Code of Federal Regulations Part 292, Section 292.203 et seq.) implementing the Public Utility Regulatory Policies Act of 1978 (16 U.S.C.A. Section 796, et seq.), or any successor requirements for Qualifying Facilities, may seek certification from FERC to have the Generating Facility designated as a Qualifying Facility or "QF." In summary, QFs are Generating Facilities using renewable or alternative fuels as a primary energy source or facilities that utilize the thermal energy given off by the generation process for some other useful purpose. QFs enjoy certain rights and privileges not available to non-QF Generating Facilities.

QF status is not required to interconnect and operate in parallel with PG&E's Distribution System.

Part IV Cont'd – Describing the Generating Facility and Host Customer's Electrical Facilities

G.	Please indicate if Generating Facility will meet the annual Efficiency and Operating Standards of PUC Code 218.6 (Applicable to Cogeneration Only)	__Yes __No __N/A

Part V – Instructions for Describing the Generators

	Generator Information	Instructions and Comments
#	Please indicate the number of each "type" of Generator being installed.	Please provide the following information for each Generator "type". Be sure all Generators classified as one "type" are identical in all respects. If only one type of Generator is to be used, only one column needs to be completed. Please be sure the information in the "Totals" column is correct and reflects the total number of Generator units to be installed.
A	Generator/Inverter Manufacturer	Enter the brand name of the Generator.
B	Generator/Inverter Model	Enter the model name or number assigned by the manufacturer of the Generator.
C	Generator/Inverter Software Version	If this Generator's control and or protective functions are dependent on a software program supplied by the manufacturer of the equipment, please provide the version or release number for the software that will be used.
D	Is the Generator Certified by a Nationally Recognized Testing Laboratory (NRTL) according to Rule 21?	Answer "Yes" only if the Generator manufacturer can or has provided certification data. See PG&E's Rule 21, Section L for additional information regarding Generator certification.
E	Generator Design	Please indicate the design of each Generator. Designate "Inverter" anytime an inverter is used as the interface between the Generator and the electric system regardless of the primary power production/storage device used.
F	Gross Nameplate Rating (kVA)	This is the capacity value normally supplied by the manufacturer and stamped on the Generator's nameplate. This value is not required where the manufacturer provides only a kW rating. However, where both kVA and kW values are available, please indicate both.
G	Operating Voltage	This value should be the voltage rating designated by the manufacturer and used in this Generating Facility. Please indicate phase-to-phase voltages for 3-phase installations. See PG&E's Rule 21, Section H.2.b. and Table H.1., for additional information.

Part V – Cont'd Instructions for Describing the Generators

	Generator Information	Instructions and Comments
H	Power Factor Rating	This value should be the nominal power factor rating designated by the manufacturer for the Generator. See PG&E's Rule 21, Section H.2.i. for additional information.
I	PF Adjustment Range	Where the power factor of the Generator is adjustable, please indicate the maximum and minimum operating values. See PG&E's Rule 21, Section H.2.i.
J	Wiring Configuration	Please indicate whether the Generator is a single-phase or three-phase device. See PG&E's Rule 21, Section H.3.
K	3-Phase Winding Configuration	For three-phase generating units, please indicate the configuration of the Generator's windings or inverter systems.
L	Neutral Grounding	Wye connected generating units are often grounded – either through a resistor or directly, depending upon the nature of the electrical system to which the Generator is connected. If the grounding method used at this facility is not listed, please attach additional descriptive information.
M	*For Synchronous Generators Only:*	If the Generator is of a synchronous design, please provide the synchronous reactance, transient reactance, and subtransient reactance values supplied by the manufacturer. This information is necessary to determine the short circuit contribution of the Generator and as data in load flow and short circuit computer models of PG&E's Distribution System. If the Generator's Gross Nameplate Capacity is 10 MW or greater, PG&E may request additional data to better model the nature and behavior of the Generator with relation to its Distribution System.
N	*For Induction Generators Only:*	If the Generator is of an induction design, please provide the "locked rotor current" value supplied by the manufacturer. If this value is not available, the stator resistance, stator leakage reactance, rotor resistance, rotor leakage reactance values supplied by the manufacturer may be used to determine the locked rotor current. If the Generator's Gross Nameplate Capacity is 10 MW or greater, PG&E may request additional data to better model the nature and behavior of the Generator with relation to its Distribution System.
O	Short Circuit Current Produced by Generator	Please indicate the current each Generator can supply to a three-phase fault across its output terminals. For single phase Generators, please supply the phase-to-phase fault current.

Part V – Cont'd Instructions for Describing the Generators

	Generator Information	Instructions and Comments
P	*For Generators that are Started as a "Motor" Only:* 1. In-Rush Current 2. Host Customer's Service Entrance Panel (Main Panel) Continuous Current Rating	This information is needed only for Generators that are started by "motoring" the generator. See PG&E's Rule 21, Sections L.3.d. and L.7.b. for significance and additional information. If this question was answered in Part IV, question C of this Application, it need not be answered here.
Q	Prime Mover Type	Please indicate the type and fuel used as the prime mover or source of energy for the Generator. 1 = Internal Combustion Engine – Natural Gas 2 = Internal Combustion Engine – Diesel Fueled 3 = Internal Combustion Engine - Other Fuel 4 = Microturbine– Natural Gas 5 = Microturbine – Other Fuel 6 = Combustion Turbine Natural Gas 7 = Combustion Turbine - Other Fuel 8 = Steam Turbine 9 = Photovoltaic Panels 10 = Solar-thermal engine 11 = Fuel Cell– Natural Gas 12 = Fuel Cell– Other Fuel 13 = Hydroelectric Turbine 14 = Wind Turbine 15 = Other (please describe)
R	AC Disconnect	For systems requiring an AC Disconnect only, please include the requested information about the AC Disconnect.
S	Photovoltaic (PV) Panel	For PV systems only, please include requested information about the PV panels.
T	Lineside Tap	PG&E has special requirements for a lineside tap. Contact PG&E at: Rule21Gen@PGE.Com for more information.

Appendix J: PG&E Form 79-978 "Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities"

ELECTRIC SAMPLE FORM NO. 79-978
Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities of 1,000 Kilowatts or Less, Other Than Facilities of 30 Kilowatts or Less T T

Please Refer to Attached
Sample Form

Pacific Gas and Electric Company

INTERCONNECTION AGREEMENT FOR NET ENERGY METERING OF SOLAR OR WIND ELECTRIC GENERATING FACILITIES OF 1,000 KW OR LESS, OTHER THAN FACILITIES OF 30 KW OR LESS

This *Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities of 1,000 kW or Less, Other Than Facilities of 30 kW or Less* (Agreement)[1] is entered into by and between _____ (Customer-Generator), and Pacific Gas and Electric Company (PG&E), a California Corporation. Customer-Generator and PG&E are sometimes also referred to in this Agreement jointly as "Parties" or individually as "Party." In consideration of the mutual promises and obligations stated in this Agreement and its attachments, the Parties agree as follows:

1. SCOPE AND PURPOSE

This Agreement provides for Customer-Generator to interconnect and operate a Generating Facility in parallel with PG&E's Distribution System to serve the electrical loads connected to the electric service agreement ID number that PG&E uses to interconnect Customer-Generator's Generating Facility. Customer-Generator's Generating Facility is intended primarily to offset part or all of the Customer-Generator's own electrical requirements. Consistent with, and in order to effectuate, the provisions of Sections 2827, 2827.7 and 2827.8 of the California Public Utilities Code and PG&E's electric rate Schedule NEM (NEM), Parties enter into this Agreement. This Agreement applies to the Customer-Generator's Generating Facilities identified below with the specified characteristics and generating capacity, and does not allow interconnection or operation of facilities different than those described.

2. SUMMARY AND DESCRIPTION OF CUSTOMER-GENERATOR'S GENERATING FACILITY AND DESIGNATION OF OTHERWISE-APPLICABLE RATE SCHEDULE

2.1 A description of the Generating Facility, including a summary of its significant components and a single-line diagram showing the general arrangement of how Customer-Generator's Generating Facility and loads are interconnected with PG&E's Distribution System, is attached to and made a part of this Agreement. (This description is supplied by Customer-Generator as Appendix A).

2.2 Generating Facility identification number: _____ (Assigned by PG&E).

2.3 Customer-Generator's electric service agreement ID number: _____ (Assigned by PG&E).

[1] Additional forms are available on PG&E's website at http://www.pge.com/net/.

2.4 Name and address used by PG&E to locate the electric service agreement ID number used to interconnect the Generating Facility with PG&E's Distribution System:

Name: _____

Address: _____

City/Zip Code: _____

2.5 Interconnected Equipment

List of generating equipment interconnected with, or without, an inverter to PG&E. (For those generators interconnecting without an inverter, write in "N/A" in the right three columns. If an inverter is shared by more than one generator, write "shared" on the same line as that generator under the manufacturer column and do not enter the inverter rating. Attach list of additional equipment, if applicable.)

	Type of Generator (Solar / Wind / Hybrid)	Generator Rating (watts)	Manufacturer of Inverter used with Generator (If Applicable)	Inverter Model Number (If Applicable)	Inverter Rating (watts)[2] (If Applicable)
1					
2					

2.6 Customer-Generator's otherwise-applicable rate schedule under the provisions of Schedule NEM will be _____

2.7 The Generating Facility's expected date of Initial Operation is _____ The expected date of Initial Operation shall be within two years of the date of this Agreement.

2.8 If the date of the permits allowing the Customer-Generator to commence construction of the Generating Facility is prior to January 1, 2009, please provide the date the permits were issued: _____

3. DOCUMENTS INCLUDED AND DEFINED TERMS

3.1 This Agreement includes the following exhibits that are specifically incorporated herein and made a part of this Agreement.

Appendix A Description of Generating Facility and Single-Line Diagram (Supplied by Customer-Generator).

[2] If installing an inverter, the inverter rating equals: (the CEC efficiency for each installed inverter) TIMES (the nameplate rating, in kW, of each inverter). The CEC efficiency is obtained on the CEC website at http://www.consumerenergycenter.org/erprebate/eligible_inverters.html as listed on the date the application is reviewed. Enter the total of all inverter ratings for multiple inverter installations in the Table above.

Appendix B — A Copy of PG&E's *Agreement for Installation or Allocation of Special Facilities* (Forms 79-255, 79-280, 79-702) or Agreements to Perform Any Tariff Related Work (62-4527), if applicable (Formed by the Parties).

In addition, PG&E Electric Tariff Rules and Rates, including but not limited to Electric Rules 2, 14, 15, 16, and 21, Schedule NEM, and Customer-Generator's otherwise-applicable rate schedule, available at PG&E's website at www.pge.com or by request, are specifically incorporated herein and made part of this Agreement.

3.2 When initially capitalized, whether in the singular or in the plural, the terms used herein shall have the meanings assigned to them either in this Agreement or in PG&E's Electric Rule 21, Section C.

4. CUSTOMER BILLING AND PAYMENT

Customer-Generator initially selects Pacific Gas and Electric Company's electric rate schedule referenced in Section 2.6 of this Agreement as its otherwise-applicable rate schedule. Customer-Generator understands that they will be billed according to the otherwise-applicable rate schedule and Schedule NEM.

5. TERM AND TERMINATION

5.1 This Agreement shall become effective as of the last date entered in Section 18 below. The Agreement shall continue in full force and effect until the earliest date that one of the following events occurs:

(a) The Parties agree in writing to terminate the Agreement.
(b) Unless otherwise agreed in writing by the Parties, at 12:01 A.M. on the day following the date the electric service agreement ID number through which Customer-Generator's Generating Facility is interconnected to PG&E is closed or terminated.
(c) At 12:01 A.M. on the 61st day after Customer-Generator or PG&E provides written Notice pursuant to Section 11 below to the other Party of Customer-Generator's or PG&E's intent to terminate this Agreement.

5.2 Customer-Generator may elect to terminate this Agreement pursuant to the terms of Section 5.1(c) for any reason. PG&E may elect to terminate this Agreement pursuant to the terms of Section 5.1(c) for one or more of the following reasons:

(a) A change in applicable rules, tariffs, or regulations, as approved or directed by the Commission, or a change in any local, state or federal law, statute or regulation, either of which materially alters or otherwise affects PG&E's ability or obligation to perform PG&E's duties under this Agreement; or,

(b) Customer-Generator fails to take all corrective actions specified in PG&E's Notice that Customer-Generator's Generating Facility is out of compliance with the terms of this Agreement within the time frame set forth in such Notice; or,

(c) Customer-Generator abandons the Generating Facility. PG&E shall deem the Generating Facility to be abandoned if PG&E determines, in its sole opinion, the Generating Facility is nonoperational and Customer-Generator does not provide a substantive response to PG&E Notice of its intent to terminate this Agreement as a result of Customer-Generator's apparent abandonment of the Generating Facility affirming Customer-Generator's intent and ability to continue to operate the Generating Facility; or,

(d) Customer-Generator's Generating Facility ceases to meet all applicable safety and performance standards set out in Section 6.

5.3 Notwithstanding any other provisions of this Agreement, PG&E shall have the right to unilaterally file with the Commission, pursuant to the Commission's rules and regulations, an application to terminate this Agreement.

5.4 Any agreements attached to and incorporated into this Agreement shall terminate concurrently with this Agreement unless the Parties have agreed otherwise in writing.

6. GENERATING FACILITY REQUIREMENTS

6.1 Customer-Generator's Generating Facility must meet all applicable safety and performance standards established by the National Electrical Code, the Institute of Electrical and Electronics Engineers, and accredited testing laboratories such as Underwriters Laboratories and, where applicable, rules of the Commission regarding safety and reliability including Rule 21.

6.2 Customer-Generator shall: (a) maintain the Generating Facility and Interconnection Facilities in a safe and prudent manner and in conformance with all applicable laws and regulations including, but not limited to, Section 6.1, and (b) obtain any governmental authorizations and permits required for the construction and operation of the Generating Facility and Interconnection Facilities. Customer-Generator shall reimburse PG&E for any and all losses, damages, claims, penalties, or liability it incurs as a result of Customer-Generator's failure to obtain or maintain any governmental authorizations and permits required for construction and operation of Customer-Generator's Generating Facility.

6.3 Customer-Generator shall not commence parallel operation of the Generating Facility until PG&E has provided express written approval. Such approval shall normally be provided no later than thirty (30) business days following PG&E's receipt of: (1) a completed *Generating Facility Interconnection Application for Non-Export or Certain Net Energy Metered Generating Facilities (between 30 kW and 1,000 kW)* (Form 79-974), including all supporting documents and payments as described in the Application; (2) a completed *Expanded Net Energy Metering (NEM) Supplemental Application* (Form 79-998); (3) a signed and completed *Interconnection Agreement for Net Energy Metering of Solar or Wind Electric Generating Facilities of 1,000 KW or Less, Other Than Facilities of 30 KW or Less* (Form 79-978); and (4) a copy of the Customer-Generator's final inspection clearance from the governmental authority having jurisdiction over the Generating Facility. Such approval shall not be unreasonably withheld. PG&E shall have the right to have representatives present at the Commissioning Test as defined in Rule 21. Customer-Generator shall notify PG&E at least five (5) business days prior to the initial testing.

7. INTERCONNECTION FACILITIES

7.1 Customer-Generator and/or PG&E, as appropriate, shall provide Interconnection Facilities that adequately protect PG&E's Distribution System, personnel, and other persons from damage or injury, which may be caused by the operation of Customer-Generator's Generating Facility.

7.2 Customer-Generator shall be solely responsible for the costs, design, purchase, construction, permitting, operation, and maintenance of the Interconnection Facilities that Customer-Generator owns.

7.3 If the provisions of PG&E's Electric Rule 21, or any other tariff or rule approved by the Commission, require PG&E to own and operate a portion of the Interconnection Facilities, Customer-Generator and PG&E shall promptly execute an Special Facilities Agreement that establishes and allocates responsibility for the design, installation, operation, maintenance, and ownership of the Interconnection Facilities. This Special Facilities Agreement shall be attached to and made a part of this Agreement as Appendix B.

8. LIMITATION OF LIABILITY

Each Party's liability to the other Party for any loss, cost, claim, injury, liability, or expense, including reasonable attorney's fees, relating to or arising from any act or omission in its performance of this agreement, shall be limited to the amount of direct damage actually incurred. In no event shall either Party be liable to the other Party for any indirect, special, consequential, or punitive damages of any kind whatsoever.

9. INSURANCE

Customer-Generator Facility is required to comply with standards and rules set forth in section 6 and provide the following for insurance policies in place.

Customer-Generator shall furnish the required certificates and all endorsements to PG&E prior to Parallel Operation.

The certificate shall provide thirty (30) calendar days' written notice to PG&E prior to cancellation, termination, alteration, or material change of such insurance.

PG&E shall have the right to inspect or obtain a copy of the original policy or policies of insurance.

9.1 If at any time during this agreement the Customer-Generator fails to meet the requirements in section 6, the following insurance shall apply:

Customer-Generator shall procure and maintain a commercial general liability insurance policy at least as broad as the Insurance Services Office (ISO) commercial general liability coverage "occurrence" form; or, if Customer-Generator is an individual, then liability coverage with respect to premises and use at least as broad as the ISO homeowners' or personal liability insurance occurrence policy form, or substitute, providing equivalent coverage no less than the following limits, based on generator size:

(a) Two million dollars ($2,000,000) for each occurrence if the Gross Nameplate Rating of the Generating Facility is greater than one hundred (100) kW; or

(b) One million dollars ($1,000,000) for each occurrence if the Gross Nameplate Rating of the Generating Facility is greater than twenty (20) kW and less than or equal to one hundred (100) kW; or

(c) Five hundred thousand dollars ($500,000) for each occurrence if the Gross Nameplate Rating of the Generating Facility is twenty (20) kW or less; or

(d) Two hundred thousand dollars ($200,000) for each occurrence if the Gross Nameplate Rating of the Generating Facility is ten (10) kW or less and the Generating Facility is connected to an account receiving residential service from PG&E.

The insurance shall, by endorsement:

(a) Add PG&E as an additional insured;

(b) State that coverage provided is primary and is not in excess to or contributing with any insurance or self-insurance maintained by PG&E.

(c) Contain a severability of interest clause or cross-liability clause.

9.2 If Customer-Generator's Generating Facility is connected to an account receiving residential service from PG&E and the requirement of Section 9.1 prevents Customer-Generator from obtaining the insurance required in this Section, then upon Customer-Generator's written Notice to PG&E in accordance with Section 11.1, the requirements of Section 9.1 may be waived.

9.3 Customer-Generator may self-insure with approval from PG&E. Evidence of an acceptable plan to self-insure, at least thirty (30) calendar days' prior to operations shall be submitted.

If Customer-Generator ceases to self-insure to the level required hereunder, or if Customer-Generator is unable to provide continuing evidence of Customer-Generator's ability to self-insure, Customer-Generator agrees to immediately obtain the coverage required under agreement.

9.4 All required certificates, endorsements or letters of self-insurance shall be issued and submitted via email or fax to the following:

Pacific Gas and Electric Company
c/o EXIGIS LLC
support@exigis.com
Fax: 646-755-3327

10. INDEMNITY FOR FAILURE TO COMPLY WITH INSURANCE PROVISIONS

10.1 If Customer-Generator fails to comply with the insurance provisions of this Agreement, Customer-Generator shall, at its own cost, defend, save harmless and indemnify PG&E, its directors, officers, employees, agents, assignees, and successors in interest from and against any and all loss, liability, damage, claim, cost, charge, demand, or expense of any kind or nature (including attorney's fees and other costs of litigation) resulting from the death or injury to any person or damage to any property, including the personnel and property of the utility, to the extent that the utility would have been protected had Customer-Generator complied with all such

insurance provisions. The inclusion of this Section 10.1 is not intended to create any expressed or implied right in Customer-Generator to elect not to provide any such required insurance.

10.2 The provisions of this Section 10 shall not be construed to relieve any insurer of its obligations to pay any insurance claims in accordance with the provisions of any valid insurance policy.

11. NOTICES

11.1 Any written notice, demand, or request required or authorized in connection with this Agreement (Notice) shall be deemed properly given if delivered in person or sent by first class mail, postage prepaid, to the person specified below:

If to PG&E: Pacific Gas and Electric Company
Attention: Generation Interconnection Services- Contract Management
245 Market Street
Mail Code N7L
San Francisco, California 94105-1702

If to Customer-Generator:
Customer-Generator Name: _____

Address: _____

City: _____

Phone: (_____) _____

FAX: (_____) _____

11.2 A Party may change its address for Notices at any time by providing the other Party notice of the change in accordance with Section 11.1.

11.3 The Parties may also designate operating representatives to conduct the daily communications, which may be necessary or convenient for the administration of this Agreement. Such designations, including names, addresses, and phone numbers may be communicated or revised by one Party's Notice to the other.

12. REVIEW OF RECORDS AND DATA

12.1 PG&E shall have the right to review and obtain copies of Customer-Generator's operations and maintenance records, logs, or other information such as Generating Facility availability, maintenance outages, circuit breaker operation requiring manual reset, relay targets and unusual events pertaining to Customer-Generator's Generating Facility or its interconnection to PG&E.

12.2 Customer-Generator authorizes to release to the California Energy Commission (CEC) information regarding Customer-Generator's facility, including customer name and Generating Facility location, size, and operational characteristics, as requested from time to time pursuant to the CEC's rules and regulations.

13. ASSIGNMENT

Customer-Generator shall not voluntarily assign its rights nor delegate its duties under this Agreement without PG&E's written consent. Any assignment or delegation Customer-Generator makes without PG&E's written consent shall not be valid. PG&E shall not unreasonably withhold its consent to Customer-Generator's assignment of this Agreement.

14. NON-WAIVER

None of the provisions of this Agreement shall be considered waived by a Party unless such waiver is given in writing. The failure of a Party to insist in any one or more instances upon strict performance of any of the provisions of this Agreement or to take advantage of any of its rights hereunder shall not be construed as a waiver of any such provisions or the relinquishment of any such rights for the future, but the same shall continue and remain in full force and effect.

15. GOVERNING LAW, JURISDICTION OF COMMISSION, INCLUSION OF PG&E's TARIFF SCHEDULES AND RULES

15.1 This Agreement shall be interpreted, governed, and construed under the laws of the State of California as if executed and to be performed wholly within the State of California without giving effect to choice of law provisions that might apply to the law of a different jurisdiction.

15.2 This Agreement shall, at all times, be subject to such changes or modifications by the Commission as it may from time to time direct in the exercise of its jurisdiction.

15.3 The interconnection and services provided under this Agreement shall at all times be subject to the terms and conditions set forth in the Tariff Schedules and Rules applicable to the electric service provided by PG&E, which Tariff Schedules and Rules are hereby incorporated into this Agreement by this reference.

15.4 Notwithstanding any other provisions of this Agreement, PG&E shall have the right to unilaterally file with the Commission, pursuant to the Commission's rules and regulations, an application for change in rates, charges, classification, service, tariff or rule or any agreement relating thereto.

16. AMENDMENT AND MODIFICATION

This Agreement can only be amended or modified by a writing signed by both Parties.

17. ENTIRE AGREEMENT

This Agreement, including any incorporated Tariff Schedules and Rules, contains the entire Agreement and understanding between the Parties, their agents, and employees as to the subject matter of this Agreement. Each party also represents that in entering into this Agreement, it has not relied on any promise, inducement, representation, warranty, agreement or other statement not set forth in this Agreement or in the incorporated Tariff Schedules and Rules.

18. SIGNATURES

IN WITNESS WHEREOF, the Parties hereto have caused this Agreement to be executed by their duly authorized representatives. This Agreement is effective as of the last date set forth below.

CUSTOMER-GENERATOR'S NAME		PACIFIC GAS AND ELECTRIC COMPANY	
By:	_____	By:	_____
Name:	_____	Name:	_____
Title:	_____	Title:	Manager, Generation Interconnection Services
Date:	_____	Date:	_____

APPENDIX A
DESCRIPTION OF GENERATING FACILITY
AND SINGLE-LINE DIAGRAM
(Provided by Customer-Generator)

APPENDIX B
(If Applicable)
Any Rule 2 or Rule 21 Agreements for the Installation or Allocation of Special Facilities (Forms 79-255, 79-260, 79-702) or Agreements to Perform Any Tariff Related Work (62-4527)
(Formed between the Parties)

Appendix K: PG&E Form 79-998 "Expanded Net Energy Metering (NEM) Supplemental Application"

Electric Sample Form No. 79-998
Renewable and Expanded Net Energy Metering (NEM) Supplemental Application

Please Refer to Attached
Sample Form

Pacific Gas and Electric Company

RENEWABLE AND EXPANDED NET ENERGY METERING (NEM) SUPPLEMENTAL APPLICATION

All Applicants for service on a Net Energy Metering rate schedule pursuant to Public Utilities Code Section 2827 who are required to complete a *GENERATING FACILITY INTERCONNECTION APPLICATION* (Form 79-974) must also complete this form. Please answer the questions below. Use additional sheets, if necessary.

A	What are the specifications for the single disconnect switch that will be used at this Generating Facility? Note: The disconnect switch must be installed in a readily accessible location normally within ten (10) feet of the service panel and in a location where PG&E can operate the switch.	Disconnect Switch Manufacturer _____ Disconnect Switch Model Number _____ Disconnect Switch Rating _____ Amps
	Can PG&E readily access the disconnect switch for this Generating Facility year-round?	Yes _____ No _____ _____ _____ (Please explain why)
B	What is the otherwise-applicable rate schedule that you are requesting under PG&E's Net Energy Metering tariff?	PG&E Otherwise-Applicable Rate Schedule _____
C	What is the power source of the Generating Facility?	Circle all that apply:

biomass	geothermal	municipal solid waste
solar thermal	fuel cell	landfill gas
photovoltaic	small hydroelectric generation	ocean wave
wind	digester gas	ocean thermal
tidal current		

Automated Document, Preliminary Statement A

Pacific Gas and Electric Company

RENEWABLE AND EXPANDED NET ENERGY METERING (NEM) SUPPLEMENTAL APPLICATION

D	When did/will you have all permits required to commence construction of the Generating Facility, and when will construction be completed?	Date permitted to commence construction _____ Date construction completed _____
E	Can PG&E readily access the Customer's service panel to read the PG&E meter year-round?	Yes _____ No _____ _____ _____ (Please explain why)
F	How many Customer-owned locked gates will PG&E need to pass through to access the PG&E meter and disconnect switch?	Number of locked gates: _____
G	Will PG&E need access to any planks or platforms, or need to cross over/under any hot-wire fences to access the disconnect switch or access the meter?	Yes _____ _____ (Please explain why) No _____
H	Does Customer receives 3 phase service from PG&E: a) What Voltage is this service? b) Is the service 3 wires (ungrounded) or 4 wires?	Yes _____ (Please answer a and b below) No _____ (Please do not answer a and b below) 240 V ____ 480 V ____ Other Voltage ____ 3 wires ____ 4 wires ____
I	If the Generating Facility will be associated with an Agricultural rate schedule per Question B, what is the total horsepower of the agricultural pump(s)?	If applicable, Horsepower (hp) _____

Automated Document, Preliminary Statement A

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Appendix L: Camp Roberts PV Power Plant 100% Design Submittal Drawings

Camp Roberts design drawings are available by contacting the PE CEM Environmental Engineer from the Environmental Compliance Branch, Naval Facilities Engineering Service Center (NAVFAC). The file name containing this information is:

- _Camp Roberts_Approved_Set_01-23-12_Portfolio.

Due to its file size of 13.7Mb, the destailed design drawings are not included in this report.